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Use of Eco-Energy in Ancient Architecture (Iranian Ice pits)

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***Abstract*—Using all the climatic factors for making necessary heat or coldness was one of the main factors of traditional architecture in Iran. Iran is located in a hot and dry area so that Iranian traditional architecture can satisfy the needs. The ice pits were places for keeping ice. By using traditional ice-pits the ice was produced in winter and saved for use in summer. The system depended on the transfer of temperature in the form of radiation from the water surface to the clean and chilly sky at cold winter nights. From this point of view, there is a need to examine early architecture. In particular, Iranian traditional architecture, in its approach to ''harmony with nature'', has developed a unique architectural culture. Iranian traditional architecture has diverse capacities to control the architectural environment in harmony with nature.**

Keywords- sustainable architecture; traditional building; ice pit; styling; yakh-chal

I. INTRODUCTION

The ice pits were places for keeping ice. The ice was provided during the cold months of the year and was used during the hot months till the following year.

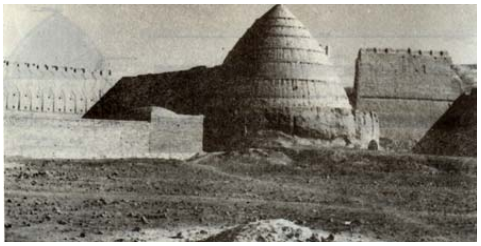

Figure 1. Maibod ice pit. (safaveye period)

With regard to this fact that Iran is located in a hot and dry area and summers are long and it is difficult to tolerate this hot weather, drinking cold water or some things like ice cream can necessitate using ice during summer. Here, we see that climate architecture can satisfy the needs as we can see:

When the weather is 40 °C in Shiraz or Kerman, cold water is always accessible (Fig. 1). It should be mentioned that the use of climate architecture and the way climate and architecture are used for making life comfortable during different seasons. It has also been present in our past architecture in different areas (Pirnia 1988).

II. ICE PITS IN IRAN

Samuel W. Matus, one of the famous writers to the National Geography Journal wrote: " The Chinese used to hoard ice in 1000 B.C. Romans and Greeks also used to keep their wine cool by putting it in the snow that was in the pits which were covered by straw, although Hippocrates believed that drinking from ice was not useful for the health. For the luxurious people having ice in the summer was an exceptional and enjoyable thing (Europe 18th century) but tourists (travelers) had said that the way ice was kept in Iran was so improved that even the poorest people could have it" (Tavasoli, 2001).

Every building material in desert town is composed of mud and its derivatives. In fact, nothing but mud and mortar can be used in such regions because there is no other building material in the region. Here, one must refer to the question of self-sufficiency in desert regions because all the earth excavated during housing construction is used as building material (Musavian, 1985). In such regions one cannot find any other form of mud. Building materials except unbaked bricks and mud strongly resist the incessant sun rays in the very warm months of July and August. In the meantime, in cold seasons, the chambers are warmed with very little heat and even the unbaked brick walls turn into massive and intact blocks after drying and are fully resistant and hardy (Heinz, 1979) (*Fig. 2*).

Figure 2. View of building materials in desert.

III. COOLING SYSTEMS IN DESERT

Due to very hot temperature the building materials first absorb the heat and then rapidly repel it. In other words, this heat and energy is preserved in the walls about 8 hours and are gradually transferred to inner compartments trough other parts of the covering. Such a quality provides two alternatives in cold and warm seasons:

In cold seasons, the absorbed temperature serves as an isolation barrier which protects the inside air from being affected by the chilly winter desert climate.

During hot seasons, the absorbed temperature causes problems and the conditions inside the building prevent comfort for residents. As a result, during nights and during sleep the people prefer to sleep on the roofs so that because of loss of temperature attracted by the roof they can feel cooler. At daytime too, the concept of using the summer quarter with the air traps which is a distinguished element for that purpose is observed, because the summer quarter is backing the sun and is to some extent immune from sun radiation. Meanwhile, the air trap operates as a ventilator and air cooler at the summer quarter of the house and plays an important role in cooling the apartment during day time, too (Varjavand , 1982).

In desert regions, the temperature at winter nights is just a few degrees above zero. Through traditional ice-builders, the ice was produced in winters and stored to be used later in summer. The ice builder was a big pit of 10-15 meters deep in which one or several shallow rectangular water lagoons were built. These lagoons had a width of 10 to 20 m from north to the south and a length of several hundred meters from east to the west (Musavian, 1985).

A tall mud wall on the southern lagoon and other shorter mud (unbaked brick) walls were set at the eastern and western sides of the lagoon to prevent the sun from shining back both during sunrise and sunset, i.e. when water was converting into ice. Under such conditions, due to the temperature loss resulting from radiation, necessary conditions were developed for freezing. The thickness of the frozen water varied according to the climate. On the following day, the ice was broken and transferred to the store. The heat flowing from earth into the ice inside the lagoons helped the ice to break and be transferred to the store.

Nowadays, water in reservoirs or the ice produced through traditional systems can be used for various purposes other than drinking. (*Fig. 3*)

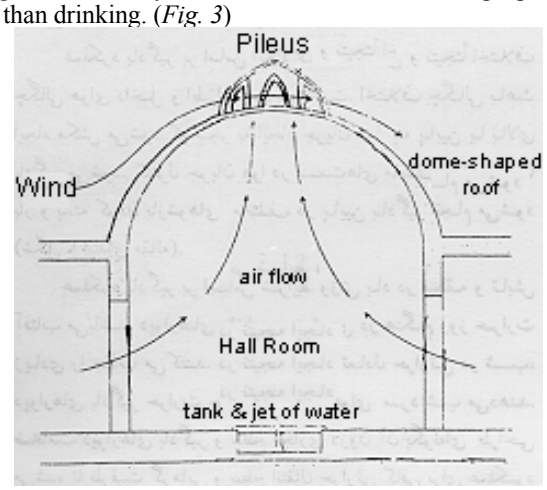

Figure 3. Typical structure of a cooling system

IV. THE WAY TO MAKE ICE

In the same way that the light of the sun and building materials were used for providing and hoarding heat , the low temperature in the night and the earth's being a nonconductor was also used for providing coldness as well as hoarding it.

Sir John Chardon , the famous French philosopher and traveler who had traveled to Iran during " Safavids " for several times and was quite familiar with Farsi (Persian Language) had written in his tourist itinerary about the way to make ice in Iran: " Ice is sold out of the city area and the way to make it is this : "in an area they make a deep hole (pit) to the north's , in front of that they make some other small pits for about 40 or 50 cm and each side is about 16 to 20 cm. Then in the night they fill them with water and in the morning when they are completely frozen, they are broken and all separate parts are put in the deep pits and there again they are broken to the smaller pieces, because the smaller the pieces are, the better they are frozen. When the ice pit is filled with a type of sea of read named powerless and is found near the water in Iran. They are covered and in summer they use this ice. Water needed for the ice pits was provided by the river (streams) and subterranean. This water was guided to the pits that Shardon had said or to the surface ground (Monshi 1987).

Because of the cold weather in winter and the heat from warm water to the cold sky at night, water freezes and in the morning, the ice goes to the tank of the ice pits. In the southern part of the crates or holes, there was a high brick wall so that during the day the place of making ice can be in the shade of the wall and the heat of the day boarded less. As a result, its temperature at night is lower in comparison to other grounds and water is frozen faster. For preventing sun

shine during sunrise and sunset, often they built walls with lower heights in the western and the eastern sides. The amount of water which freezes depends on the temperature and the sky's being cloudy or not the night when the weather is cold and there is no cloud in the sky (cloud is like an insulation between the earth and the sky). They could have deeper water for freezing. But in warmer nights or cloudy sky, they use less deep water.

V. THE WAY TO PRESERVE ICE

To preserve ice for a long time a good insulation was needed. For this purpose, they preserved ice in a pit. Preservation of ice was conducted in three ways and three types of ice pits were common in Iran. Here, we explain the way to make and use them.

A. Domed ICE PIT

The ice pits over whose there was a big brick dome and it is near the central desert or north-east areas. This ice pits had a big conical pit. Below the hole, there was a way for water and when the ice melted through this way, it was conducted to the hole. The size of the pits was different. One of Iran's biggest ice pits is Maibod ice pit (Fig. 4). The mouth of this ice pit is 13 meters wide and it is about 6 meters deep. Around this pit, there is a platform whose width is 1.5 meters. Passed by this platform, there is a crust of dome which is very thick (Pirnia 1988).

To keep the dome more and decrease the cost of its building, the thickness of the dome decreases from bottom to the top so that the weight of the dome decreases and gravity center is placed in the lower height and the equipments and physical power is used less (*Fig. 5*). Maibod Dam is about 15 meters high and its down thickness is 240 cm. on top is 20 cm. because of this the ice pit's dome looks like a staircase from outside. And this is a positive point for fixing and keeping the large domes because a large number of bricks should be put on the external surface of the dome annually, so that it is preserved against rain, sun and the changes in the atmosphere.

Figure 4. Maibod ice pit, a domed ice pit.

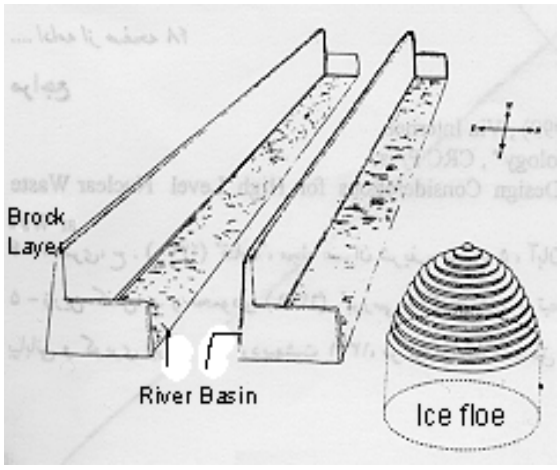

Figure 5. General view of a domed ice pit

Actually, between these stairs, they built smaller stairs so that workers could go up and down. Usually, in the southern part of the dome there was a shading wall. Its 2 meters wide and southern wall is 4 meters high and the eastern and western walls are 20 meters. The ice pits often had 2 doors, one of them was northward between the freezing place and the pit and the other one was in the southern side of the ice pit. In winter, the northern door was used and ice was brought to ice pits from the freezing place. And through the steep between door and pit, the ice was brought to ice pit. The southern door was opened during summer and ice pit keeper delivered this ice to the people through this door. When they didn't use the doors, they closed it over the wall of brick. In the southern side of the pits, there were stairs so that the ice pits keeper could reach to the lower layers. The reason that some ice pits were on the highest place in some cities and villages like (Maibod , Yazd , Zavareh in Isfahan) is that during hot days in summer especially in central desert that the sun warmed inside the ice pit , the heat went to the higher position and lower surface would be cool (Monshi 1987) .

B. UNDERGROUND ice PIT

Another type of ice pits was made in north central part of Iran like Tehran and Saveh. It could work domed ice pit, but its shape was different. A large part of this ice pit was under the ground and its thick walls were built by cements, stone (*Fig. 6*).

As you can see in the picture 6, after freezing in the crates, they were brought to the ice pits through the door under the domes. Then, they pour water on the ice so that they are united. In these ice pits, they didn't put straw between the layers of ice and over the ice itself, because the climate of these areas was cold and the ice could remain frozen until summer. In summer, the ice pit keeper would give the ice to the people through the door which was below. This door was connected to the ground by stairs. Most underground ice pits were domed once. They were large and they needed a wide and vast area to make ice. The ice was intended to be cheap, so the ice pits were built on the inexpensive urban land.

Figure 6. Saveh ice pit

C. *ICE PITS WITH no ROOF*

The third type of the ice pits that didn't have any roof were built in Esfahan and like other traditional ice pits were used until 30 or 40 years ago. This type of ice pit had a wall with 4-5 meters high and 12 meters long. In the northern side of this wall, there was a pool with 5 or 6 meters deep and its width and length were 5×12 (Pirnia 1988) . The ice was made overnight in the same way that was explained in the first chapter of this book and it was transferred to the pool in the early morning.

VI. CONCLUSIONS

This study examines the natural environment control system of Iranian traditional architecture. Problems with Iranian contemporary architecture are illustrated by comparing the environmental control of Iranian contemporary architecture with Iranian traditional architecture.

Therefore, there is a need for another orientation of architecture. Architecture should coexist with nature. This does not mean that contemporary conveniences should be abandoned, but that they need to coexist with nature. For this purpose, there is a need to make architecture control its environment according to the natural environment. This would minimize the number of problems caused by new technologies as well as to reduce energy consumption and environmental pollution. Iranian traditional architecture and its architectural environment control system can be applied to contemporary architecture. It is hoped that this paper will be useful to architects whose aim is to improve the architectural environment.

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