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The Earth And Ice-pits Sustainable Architecture In Iran

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Abstract

Many architects hold the view that Iranian traditional architecture has proved to be successful in creating innovative and sustainable architecture especially in hot-arid parts of the country. Among those architectures, an ice-pit or Yakh-chal is a clear-cut example. An ice-house (or *a Yakh-chal* literally meaning "ice-pit", *Yakh* meaning ice and *Chal* meaning pit) is a reservoir to store and preserve ice. To preserve ice for a long period of time, the earth as a good thermal insulation has been chosen. On the other hand, recent researchers have identified earth-sheltered or underground architecture as an innovative design for reducing and saving energy. The paper goes through the many benefits of earth which encourage us to build such buildings in special places. The way the earth works with the surrounding environment to fulfill our needs is another issue discussed in this paper. The paper aims at evaluating Ice-pits' sustainability, regarding all the factors which are influential in its sustainability, and suggests using their features in modern architecture and in proportion to today's technology. This research includes literature review, observation and site visits to achieve a practical solution.

The study shows that during the whole process of making and preserving ice, there was no need to consume any kind of energy but manpower. Thus from technical point of view, they were quite beneficial. They were made of mud bricks which are a good material for saving energy in deserts. Ice-pits actually addressed people's expectations, and can be considered as a source of inspiration for the next generation of architects.

Keywords: Ice-pits, sustainable architecture, earth, energy, saving

1. Introduction

More than one-third of the earth's land surface (about 36%) is considered arid or semi-arid and is found mainly between 15° and 35° north and south of the equator[3]. In general, the hot-arid zone is where the greatest amount of solar radiation is encountered. The climate is stressful with extremely high temperatures, dust-laden winds, and intense radiation together with ground reflection. The diurnal range of air temperature is large and can be as high as 17 ◦C or more [3]. Among the many types of desert climate, there is one where the use of earth-sheltered construction is thought to be most suitable; the very hot and dry climate found in some parts of Iran. Indeed, Iranian architects did find earth-sheltered construction very convenient in hot-arid parts of Iran, providing comfort for the users. Among those constructions, ice-pits (Yakh-chal) have been considered in this paper. In the first place, the basic principles of earth as a sustainable source have been discussed in order to find out it's features. In the next stage, Ice-pits are introduced as an earth-sheltered construction, using the earth's features. Finally sustainability is considered in ice-pits according to the existing sustainability factors. The paper aims at introducing the earth as a sustainable source and ice-pits as a traditional sustainable architecture.

2. Earth-sheltered or underground structures

Recent research has identified earth-sheltered or underground structures as one type of innovative design as an alternative to conventional aboveground buildings for reducing total energy requirements as well as peak load demands[3]. This new but in a way very ancient type of architecture requires no new technology. No scientific breakthroughs are necessary to enjoy the advantages that exist in subterranean structures [3].

1.2. Basic principles for energy-saving through earth sheltering

Here are some basic principles for energy-saving through earth sheltering. These energy-saving principles are incorporated in most energy-conserving earth-sheltered buildings including ice-pits. Although earth is a poor insulating material, it can insulate effectively because it is massive enough. The fact that heat loss must flow vast distances makes earth a suitable blanket in which to wrap a building [2]. In fact, the soil enclosing an underground building reduces the heat transfer from its surroundings [3]. Earth sheltered buildings are mostly protected from the direct solar radiation [1] which is very crucial in hot-arid parts of Iran. The temperature of the earth just a few meters below the surface is stable in the 5-15°C range all year long [2] and is subjected to smaller temperature fluctuations than surface building. Even at very shallow depths, the ground temperature seldom reaches the outdoor air temperatures in the heat of a summer day [3]. In fact, when the weather is extremely hot, the earth provides a source of cooling. In essence, the earth moderates the environment in which the building is located [2]. Earth sheltering also reduces the infiltrated outside air. With the earth covering most of the envelope of a building, the

building can be made more airtight [2]. In surface structures, up to 35% of heat loss can often be attributed to air infiltration. An earth-sheltered building offers greater opportunity to control the rate of outside air supply to the interior of a building [2]. All these principles have been adopted by Ice-pits.

2.2. Earth-sheltered structures in Iran

To provide cold water in hot-arid parts of Iran, two kinds of buildings were constructed but with the same approach, Ab-anbar (water reservoir) and Yakh-chal (Ice-pits) which both rely on earth to a large extent. An ab-anbar is a traditional reservoir of drinking water and its storage was built under ground to withstand the pressure the water exerts on the containers of the storage tank [4]. But the most important reason for which Ab-anbar was built underground has been overlooked and it is the power of earth. Since much research has been done on ab-anbar, we preferred to study Yakh-chal or Ice-pits.

3. Ice-pits in Iran

1.3. Definition

An ice-house (or *a Yakh-chal* in Persian literally meaning “ice-pit”, *Yakh* meaning ice and *Chal* meaning pit) is a reservoir to store and preserve ice [5]. Ice repositories in Iran were public and free charge, so all people could use ice in hot-arid parts of Iran. Architectural elements are discussed in the following:

2.3. Architectural elements

TABLE 1. shows the architectural elements of Ice-pits

The Shading Wall	The Provision Pool	The Ice Reservoir
The shading wall was a long mud wall standing to the south of the ice-making channel, casting shadow on the shallow ice making channel and stretches from the east to the west. The height of this wall might be up to nearly 10 m. The Wall prevented the sun's radiation from shining on the frozen water in the front pond [5]. The shading wall was beneficial because the temperature difference between the sun-lit and the shaded area in these areas is about 15-20 degrees.	This pool was located north of the wall and its water was provided from the rivers (streams) and subterranean. Square in shape, the channel was approximately 100m.x10 m with a depth of about 40-50 cm [5]. This pool was used for preparing ice during cold winter nights. At nights, the temperature is low and water can freeze more quickly. Coldness of winter takes the heat of water away at night and consequently the ice is formed. When they were completely frozen, they were broken [6] and transferred to the main structure which was the southern pitfall.	These reservoirs were usually located behind the shading wall. The Ice was preserved in an underground well. Three kinds of Ice-pits were prevalent in Iran that will be described in the following [5].

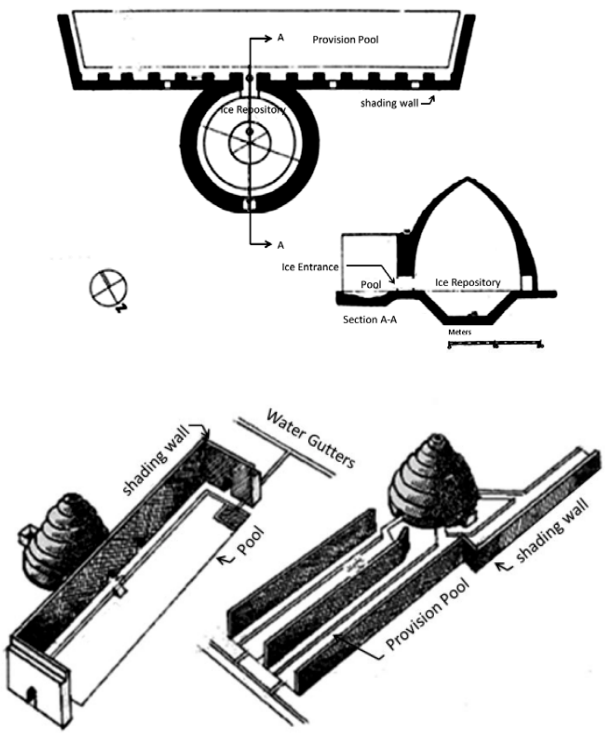

Fig 1. Left, Meibod Ice-pit in Yazd, this structure with a height of 15m is one of the tallest ice-pits in the city. Right, shading walls in the examples from Yazd [5].

Fig 2. Domed Ice-pits in Meibod and Abarku, Yazd, http://graphic.ir, http://dadaryha.com, [5]

Fig 3. An ice-pit in Kashan, Dome, hatch and ice reservoir are shown, photos by Korsavi.

3.3. Different kinds of Ice-pits

TABLE 2. shows different kinds of Ice-pits

Domed Ice-pit	An underground Ice-pit	Roofless Ice-pits
In north-eastern regions and the central desert, there was a big brick dome above an almost great pit. The pit was surrounded by a dome whose thickness diminishes from beneath to the top to provide more endurance and stability [5]. This also reduced the construction costs as less material and labor forces were employed.	Another type of ice-pit was made in north central parts of Iran and It worked like domed ice-pit, but its shape was different. A large part of this ice-pit was under the ground and its thick walls were made of cements and stone[6].	The third kind of Ice-pit called "Roofless Yakhchal", was without roof. It consisted of just two main parts, the shading wall and the pools in front of it. The provision pools were regarded as the storage for the ice in these ice-pits [5].

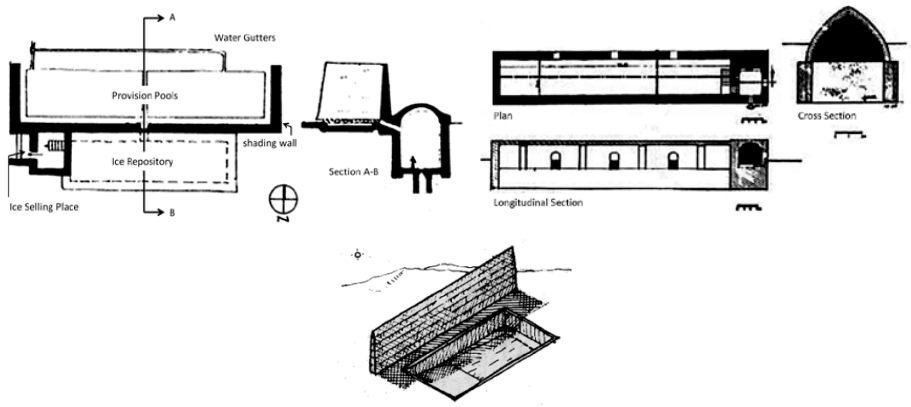

Fig 4. Left and middle show underground ice-pits. Right shows a kind of roofless ice-pit[5].

4.3. How do Ice-pits work

Generally all the principles mentioned for saving energy through earth sheltering could be adopted by Ice-pits. These principles are effective insulation, heat transfer reduction, solar radiation protection, temperature stability, smaller temperature fluctuations, moderating the environment, reduction of infiltrated outside air. Moreover, rather cold and fresh air could enter through the hatch that was placed by the shading wall. Indeed, the air came from a shaded area which was at least 10-15 degrees colder than sun-lit area so the exhausted air went up and existed from a hole on the top of the dome. Actually, cold air replaced warm air and ventilation could took place more efficiently when domes were exposed to sun radiations. Fig 5 clearly shows different parts of a domed ice-pit and their function.

1. The area in which the Ice is prepared, consisting the ponds and the shading walls[5].

2. The ice reservoir where pieces of wood and straw are used between layers of ice to prevent them from sticking to each other.

3. A well at the bottom of the reservoir is placed to vacate the melted ice.

4. The exhausted air exists through the hole.

5. Thick Masonry dome with its external thatched envelope plays an important role to prevent thermal conductivity[5].

6. According to the principles mentioned, the container has winter's temperature during hot seasons.

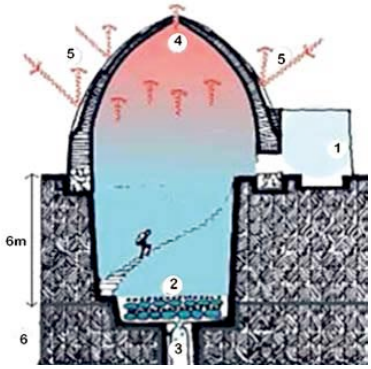

Fig 5. shows general section of the reservoir of a domed ice-pit, [5].

4. Discussion

This paper examines Iranian traditional ice-pits which coexisted with the nature. This kind of architecture was mostly derived from climatic conditions. These buildings provided the context for more comfort in harsh and severe climatic conditions. These buildings were quite advantageous to all of the people therefore during ice making period, most of the people collaborated to make ice, suggesting a common alliance in community thanks to such an architecture. Ice-pits have not only addressed the environmental aspects of sustainability, but also the social and economic aspects. To illustrate, Table 3 is presented.

TABLE 3. considers ice-pits in terms of sustainability factors

Sustainability factors		**Sustainability in ice- pits**	**Reference**
Environmental	Regional Priority	They were exactly in proportion to the regional and climatic features.	LEED Factors
	Innovation in Design	Their form, structure and the way the they used the power of earth all indicate that they were innovative designs.	
	Materials & Resources	The ice-pits' materials were local and had endurance and stability. In fact, Masonry dome with a large thickness and its external thatched envelope prevented thermal conductivity.	
Economic	Energy& Atmosphere	Cooling Ice-pits consumed no energy and its construction was economic thanks to local materials and people's collaboration.	LEED Factors
Social	social justice (equal opportunity and the achievement of all human rights)	Ice-pits were not the exclusive privilege of a special group and every one could use ice.	[7, 9]
	Solidarity (empathy, cooperation, and associational life)	People collaborated to construct ice-pits, break and transfer ice to the pit. They actually formed a society trying for the same reason and every one played a meaningful part. After working continuously for producing ice, people gathered and celebrated their success.	[7]
	participation (opportunities for everyone to play a meaningful part in development)		[7, 9]

5. Suggestions

Industrial refrigerators are the most important reason for which Ice-pits were left unused. Although the application of the Ice-pits may not seem reasonable these days, their benefits should not be overlooked. A lot of merits can be seen in these buildings which are worth considering. The meaningful form, using local materials, using earth features, structural stability, natural ventilation, respecting users and adopting the right strategy toward fulfilling users' needs all can be attributed to a successful architecture. Surely these benefits can be adopted by the next generation of architects in different buildings and constructions. As Hadi Mimiran was inspired by the form of ice-pits and designed a sport complex in Rafsanjan, Iran similar to a domed ice-pit.

Fig 5. shows a sport complex in Rafsanjan by Hadi Mimiran

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