The Earth Refrigerators as Earth Architecture

H. Niroumand, M. F. M. Zain, and M. Jamil

***Abstract*—This paper is presented an application of earth refrigerator to energy conservation. In this research, Earth refrigerators of Yazd are selected as earth architecture because about 440 BC, Persian peoples had already domination the technique of saving energy in the summer middle in the Iran desert. These structures have a large earth brick dome and height of 65 feet. The earth refrigerators are above of ground because they needs to community to Qanat and wind catcher in desert area. The earth refrigerators area is over of 5750 m^3 in Iran desert. Qanat is a water management system used to provide a valid supply of water to human settlements and for irrigation in hot, dry and semi-dry climates. The earth refrigerators of Iran desert are included thick walls. The walls are included special mortar called Sarooj. The Sarooj is involved clay, egg white, goat hair, sand and different special materials in special values. The Sarooj can resist to energy transfer. The Earth refrigerators are a complex technology. The Earth refrigerators would be valuable for energy conservation.**

***Index Terms*—Earth refrigerator, Qanat, energy, Sarooj, Yazd, Iran desert.**

I. Introduction

The storages are a place for saving of water or foods; an Earth refrigerator is a well for saving & maintenance of ice. The ice provided in winter season in Iran desert because the air was very cold due to decrease of night temperature. The people of desert area provided ice in winter and they saved their ices in Earth refrigerator for summer until next winter. The Earth refrigerator is used for maintenance their food and meat in desert area. An Earth refrigerator is an ancient type of refrigerator that their work is saving of energy. [3]

The meaning of Yakh – chal is ice pit that it is included of structure had a domed shape but it had a Qanat storage space that the Qanat space coupled with the thick heat resistant construction material insulated the storage space year round. Fig.1 shows earth refrigerator in Meybod. [7]

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Fig.1. Earth refrigerator in Meybod

The earth refrigerators are best solution for saving energy in different countries deserts. The Earth refrigerators are aboveground and they were mainly built and used from hundreds years ago in Iran desert. Fig. 2 shows earth refrigerator of Mobedi in Kerman.

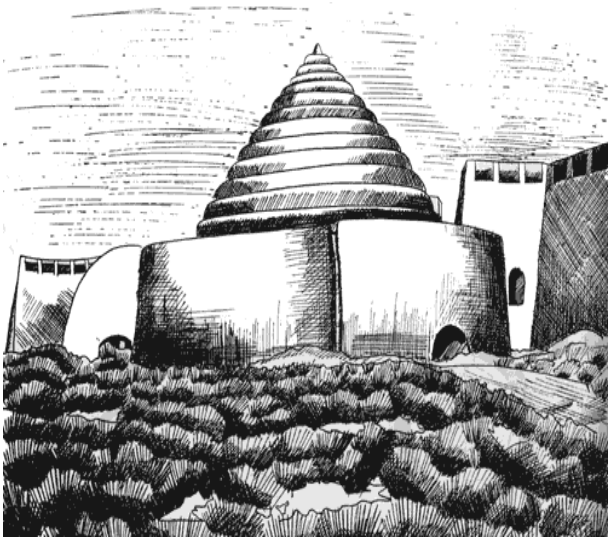

Fig. 2. View of earth refrigerator of Mobedi in Kerman

II. Introduction with Desert of Iran

Iran is situated in a high-altitude plateau surrounded by connected ranges of mountains. The well-known deserts of Iran are at two major regions: 1) Dasht-e-Kavir, and 2) Kavir-e-Lut. They are both some of the most arid and maybe hottest areas of their kinds in the world. Fig. 3 shows earth refrigerator in Bam. [7]

Fig. 3. Earth refrigerator of Bam

A. The desert Pits of Iran

Kavir-e-Lut is the largest pit inside the Iranian plateau and probably one of the largest ones in the world. Kavir-e-Lut is a pit formed by broken layers of the earth. Dasht-e-Kavir is a geological pit almost at the north of Kavir-e-Lut. The major part of Dasht-e-Kavir is covered by sand and pebbles and exposed to strong winds and storms that set salt-combined sand in motion like sea waves. The temperature difference is between 0 and 70 degrees C between days and nights during a year in Dasht-e-Kavir. [7]

B. The Ecological Conditions in Desert

Some of the ecological features of the deserts in Iran are strong sunshine, relatively little humidity, little rainfall and excessive vaporization. Depending upon how far a point is from higher altitudes, temperature is varied.

A point far from altitudes can reach up to 70 degrees C during summer. The average temperature during January and May are 24 degrees C and 42 degrees C respectively. [6]

III. Earth Refrigerator

In 440 BC Iran, Iranian people had already domination the technique of storing ice in the middle of summer in the desert. The ice was brought in during the winters from nearby mountains in bulk amounts, and stored in a specially designed, passively cooled refrigerator, called an Earth refrigerator. This was a large underground space that had thick walls made out of a special mortar called sarooj, composed of sand, clay, egg whites, lime, goat hair, and ash in specific proportions, and which was resistant to heat transfer. This mixture was thought to be completely water impenetrable. The space often had access to a Qanat, and often contained a system of wind catchers that could easily bring temperatures inside the space down to frigid levels in summer days.

IV. Qanat

A Qanat is a water balance system used to provide a reliable supply of water to human settlements and for irrigation in hot climates. Qanats are constructed as a series of well-like vertical shafts, connected by gently sloping tunnels. Qanats tap into subterranean water in a manner that efficiently delivers large quantities of water to the surface without need for pumping. The primary applications of qanats are including cooling and ice storage.

Qanats used in conjunction with a wind tower can provide cooling as well as a water supply. A wind tower is a chimney-like structure positioned above the house; the one of its four openings opposite the wind direction is opened to move air out of the house. Incoming air is pulled from a Qanat below the house. The air flow across the vertical shaft opening creates a lower pressure and draws cool air up from the Qanat tunnel, mixing with it. The air from the Qanat was drawn into the tunnel at some distance away and is cooled both by contact with the cool tunnel walls and by the giving up latent heat of evaporation as water evaporates into the air stream. In dry desert weather this can result in a greater than 15°C reduction in the air temperature coming from the Qanat; the mixed air still feels dry, so the basement is cool and only comfortably moist .Wind tower and Qanat cooling have been used in desert climates for over 1200 years. Fig. 4 shows Qanat. [2]

Fig. 4. View of Qanat

V. Wind Catcher

A wind catcher is a traditional Iranian architectural device used for many centuries to create natural ventilation in buildings. The performance of wind catcher on several roles: First, a wind catcher is capped and has several directional ports at the top. By closing all but the one facing away from the incoming wind, air is drawn upwards using their effect, similar to how opening the one facing the wind would push air down the shaft. Therefore, the key to generating frigid temperatures seems to be that there are very few cracks at the base of the thick structure below, but there is a significant air gap above the Qanat. A Qanat has quite a lot of water inside, because there are frequent well-like reservoirs along its path. Completely shaded from the sun, a Qanat also aggregates the cold, sinking air of the night, which is then trapped within, unable to rise up to the less dense surface air. Although a

wind catcher can make a pressure gradient this sucks at least a small amount of air upwards through a house. This cool, dry night air, being pulled over a long passage of water, evaporates some of it and is cooled down further. [1]

Finally, in a windless environment or waterless house, a wind catcher functions as a solar chimney. It creates a pressure gradient which allows less dense hot air to travel upwards and escape out the top. This is also compounded significantly by the day-night cycle mentioned above, trapping cool air below. The temperature in such an environment can not drop below the nightly low temperature. So effective has been the wind catcher in Iranian architecture that it has been routinely used as an Earth refrigerator for ages.

VI. Energy Conservation in Earth Refrigerator

To maintain and energy conservation need to have a good thermal insulation for long time. Therefore, the ice, food and meat into the underground area that is dug into the ground, the preserve said. The Earth refrigerators are involving of earth bricks that they made sarooj. The Sarooj is a strength material that it reduced energy transfer in Earth refrigerator. Fig. 5 and Fig. 6 show energy conservation in Qanat & wind catcher in earth refrigerator.

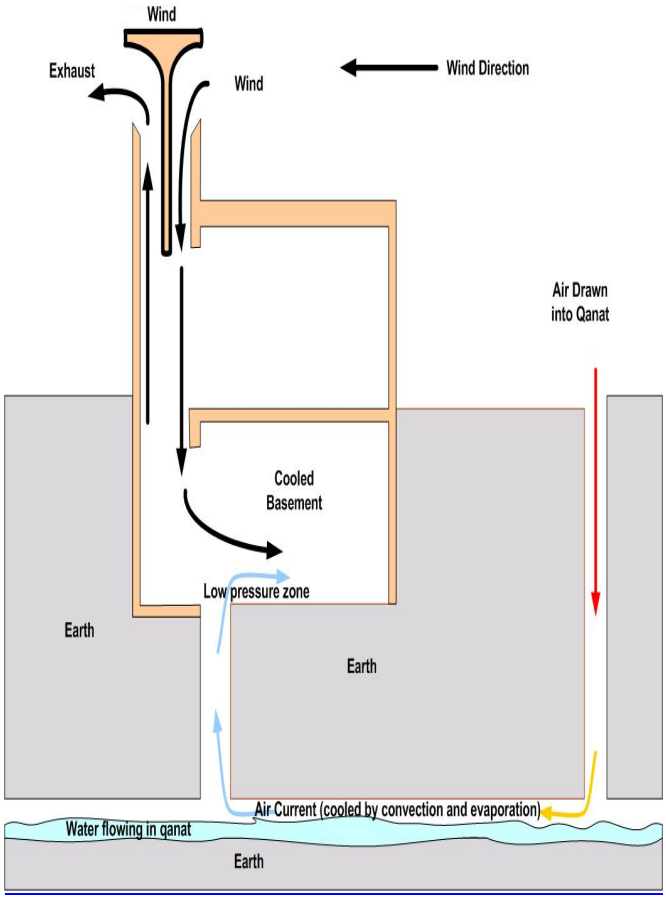

Fig. 5. Energy conservation in earth refrigerator

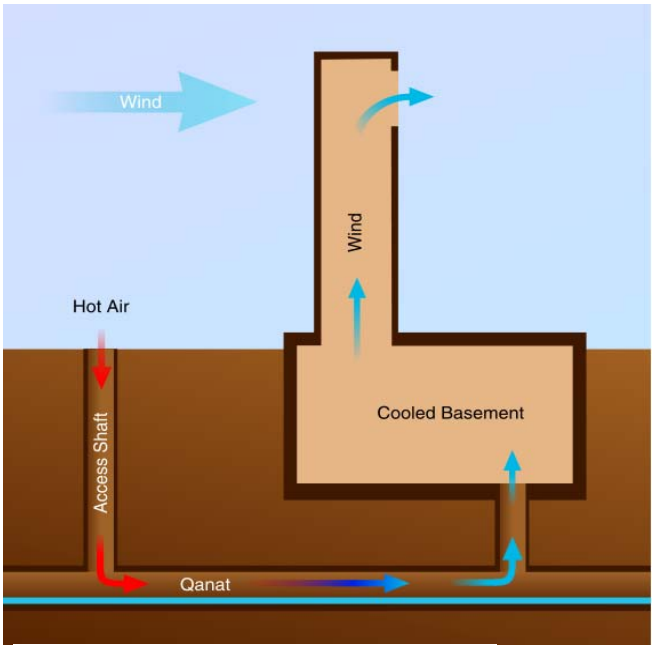

Fig. 6. Energy conservation in Qanat & wind catcher in earth refrigerator

Height of the dome in Earth refrigerator is very long in some area, the highest or one of the highest buildings of the city or village is reason during the hot summer days, especially in the margins central sunlight inside the Earth refrigerator to worm, heat in height should be higher and lower levels of cooled. Fig. 7 shows earth refrigerator in Iran desert. [4],[5]

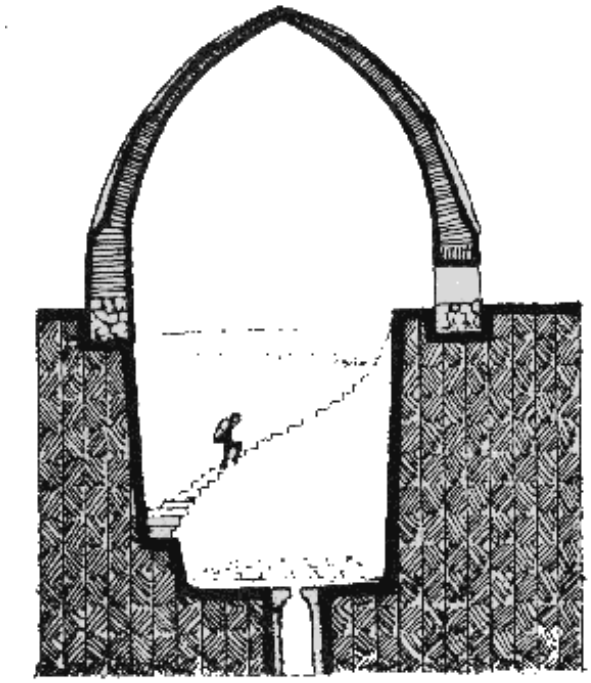

Fig. 7. Requirements earth refrigerator in Iran desert

VII. Conclusion

Mud architecture and their building have many applications in different parts that it can do as new researches in future. This paper showed that mud structures will use in different applications because they had good properties in

architecture, energy conservation, material and culture in any country. The Earth refrigerators were a good idea for development of new methods for energy conservation in desert area. This paper showed mud bricks as a good material that can use in near future.

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