A[VG1][VG2][H3] GLANCE AT HISTORICAL QANATS IN IRAN WITH AN EMPHASIS ON VAZVAN QANAT IN ISFAHAN

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ABSTRACT

Qanat is a way of conveyance of underground water to ground surface for irrigation and drinking. This is a technology born and developed in Iran and extended to other countries in the East and the West over the time. The total number of Iranian Qanats is 18000 and their total discharge is about 7.4 billions cubic meters. Among the Iranian Qanats some of them are specific from the point of view of mother well depth, length, rate of flow, oldness and attractiveness. Keikhosrow Qanat in Gonabad (Khorasan Province) has the deepest mother well, that is 400 meters. One of the Yazd Qanats has the largest tunnel that is 116 kilometers. The most flow rate Qanat is Payekam Qanat in Bam suburb which is 312 lit/s. From innovation and talent point of view, there are few historical Qanats in Isfahan such as Moon Qanat in Ardestan in which the tunnel has two parallel floors and Vazvan Qanat in which flowing water is collected beyond an underground dam for a period for irrigation purposes over the following year. There are a large number of benefits resulted from Qnanats, and few disadvantages as well, but the benefits are more. If the idle Qanats are repaired and renewed, then the rate of available water will be 1.7 billions lit/s, i.e. 4 times of Karroon River in Iran or ¾ of Nile River in Egypt. But from author's point of view, this is not possible, because of shortage of rainfall and falling water level tables which had been happened due to huge number of dug wells.

1. INTRODUCTION

"Qanat digging technique is an important ancient innovation in Iran. Recognition of its social, technical, operational, managerial and cultural dimensions is vital in understanding of the system" (Semsar et al, 2006). Qanat is a way of conveyance of underground water to ground surface for irrigation, drinking and other purposes in Persia since ancient time (Tolman, 1937). Qanat was a technology born and developed in Iran and its innovation backs to 800 years B.C. According to Goblot (1973), evolution of this art can be found just in Iranian culture and its most attractiveness could be found in Gonabad (Iran), not in elsewhere in the world. Later on, this human art had been extended to more than 34 countries in the East and the West over the time (Behnia,

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1988). Due to this great innovation many investigators and writers called Iranian civilization as a Qanat or a hydraulic civilization. The oldest Qanat which was discovered in the North of Iran had been excavated for 3000 years, i.e. as old as Aryans arrived in Persia (Behnia, 1988).

Qanat conveys water to ground surface without utilizing any electrical or mechanical power. According to Petroschifescy (1976), some times not far away there were 18400 lines of Qanat running in Iran. The sum of water rates from this huge number of Qanats was enough for irrigation of 1.5 millions hectares lands.

There are many different definitions about Qanat. For example, Goblot (1973) who refers to 534 references about Qanats in his book defines: "Qanat is a way of exploitation of underground water by using a drained corridor". One of the most general and complete one is as follows: A number of wells and one or more tunnel, with a slope less than ground surface slope that collect and convey underground water that is available in sub-surface layers of high level regions of lands, rivers, ponds and lakes, under gravity force without consuming additional electrical or mechanical energy to low level points, is called Qanat (Behnia, 1988). Indeed, Qanat is an underground drained gallery that collects drained water and conveys to ground surface for irrigation and drinking (Jahad Sazandgi, 1981 and Agricultural Committee of Jahad Sazandgi of Isfahan, 1982). There are more than 27 names in Persian, Arabic and other languages for this hydraulic structure, but the famous names are Qanat, Canat and Kariz. (Razavian, 1979).

2. ESPECIAL QANATS

There are different figures stand for the number, length and discharge of Qanats in literature. The total number of Iranian Qanats range from 4000 to 50000 and the total length recorded from 160 to 350 thousands kilometers and the total recorded discharges changes from 238000 to 1000000 lit/s. However, among these the most reliable and newest figures are the figures issued by Office of Water Resources Researches of Iran Ministry of Power. The figures of Qanat number and discharge are 18388 and 7.359 billions cubic meters respectively (Programming and Management Organization, 1981). But it is not clear that this number does or does not involve all commission and deserted Qanats. Among the Iranian Qanats some of them are specific from viewpoint of mother well, length, rate of flow, oldness and attractiveness. Among the working Qanats, the Keikhosrow Qanat in Gonabad (Khorasan Province) has the deepest mother well, that is 400 meters. This one backs to 13^{th} century B.C (Goblot, 1973). One of the Yazd Qanats has the largest tunnel that is 116 kilometers. The most flow rate Qanat is Payekam Qanat in Bam suburb which is 312 lit/s (Kerman Regional Water Company, 1984). From innovation and talent point of view, there are few Qanats in Isfahan such as Moon Qanat in Ardestan in which the tunnel has two parallel floors, that is one is above the other. This one depicts the curiosity, talent and accuracy of Iranian hydrologist, master well diggers in the history (Figure 1).

Obviously, the length of Qanat depends on the climate conditions. This means the more rainfall of a region is, the length of Qanat will be less and the depth of mother well will be shallower and vise versa. The reason is the availability of water level at upper horizon in humid region.

The excavated Qanats in deserts have the deepest well and longest tunnel compare to humid and semi humid regions. In these regions the pervious layer are so thick and Impervious layers might be more than one hundred meters below the ground surface. Some times, the depth of Qanat well reaches to 400 m, especially in central, southern and southern east regions of country.

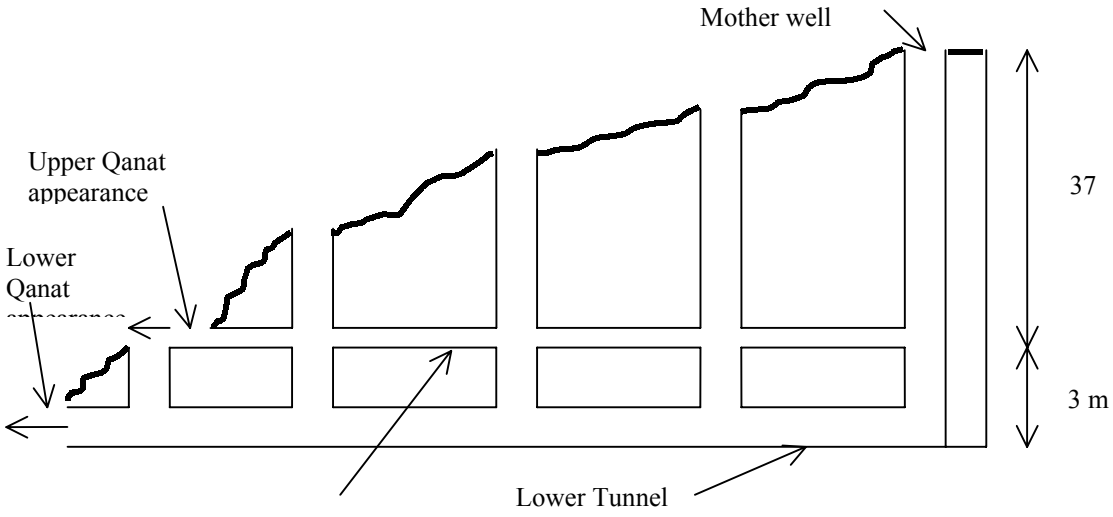

Figure1. Longitudinal section of Moon Qanat in Ardestan, Isfahan Province

Some times calcium and magnesium bicarbonates and / or calcium solphates deposit in Qanat bed. The materials that deposit in Qanat bed are called Zangabeh. The composition of Zangabeh is mostly bicarbonate which is solute in water. Of course, these materials deposit on Qanat bed where the tunnel converges to ground surface and water temperature rises. These materials, some times, block the water way that should be removed every year.

Compare to deep wells and electric pump, Qanat has several advantages such as:

1- Its beneficial life time is more
2- Its flow rate duration and yield is safer
3- It does not consume any electrical or fossil energy. It just runs by gravity force.
4- No need to access road for transportation,
5- It does guarantee the safety yield of ground water. In other words, wells spend capital, but the Qanats consume its obtained benefit.
6- No need for skilled workers and guard,
7- The cost of maintenance is low,
8- It is a good pattern of cooperation system and has a positive role in developing this system.

9- It is an effective drainage method locally and regionally and prevents rising underground water surface.

10- It is simple to be dug by domestic workers with simple tools,

11- It prepares job for people,

12- It does not necessary to spend dollars,

According to Goblot (1973), if the idle Qanats are repaired and renewed, then the rate of available water will be 1.7 billions lit/s, i.e. 4 times of Karroon River in Iran or ¾ of Nile River in Egypt. But from author's point of view, this is not possible, because of shortage of rainfall and falling water level tables which had been happened due to huge number of dug wells.

In spite of large number of benefits come from Qnanats, there are also few disadvantages as follows:

1- Technology of digging Qanat is not still modern. So, it will take a long time to excavate one with traditional tools,

2- Qanat excavation is a hard low income job. Unfortunately, no replacement had been performed for many practitioners and skilled diggers who have changed their jobs or died so far.

3- Rise of salaries for worker and high cost of construction materials disable the farmers to maintain and dreg the Qanat galleries,

4- It is not easy to save or control water flow during the non agricultural season, so a large amount of water is lost,

5- Natural disasters such as floods, earthquakes and enemy vandalisms are big problems for security of Qanats,

6- The eventuality of water contamination is high, especially when Qanat passes through cities or villages,

7- Penetration causes a large amount of water to be lost in dry section (this section is called Khoske Kar),

8- Risk of life for Qanat diggers who dig one, but it seams still to be less than for mines worker,

3. VAZVAN QANAT

Among the historical qanats in Iran, Vazvan Qanat is a great Iranian innovation and talent in the past. This is because of construction of underground dam to store water. Regarding the Qanat disadvantages written in previous section, few of the them have been solved and some had not been yet. For example, water saving had been carried out during the non agricultural season by constructing an underground dam in Vazvan Qanat in Isfahan suburb.. Some of the properties of this Qanat are depicted in Table 1.

Vazvan Qanat dated to 3000 years ago, as reported by people. In this Qanat flowing water is collected beyond an underground dam for the period of Nov 20^{th} to Apr. 20^{th} every year. This dam is a thick wall made in a well that is 600 meters far from the

mother well. Diameter of this well is three meters longer than other wells. This well is located on the intersection of wet (Tar-e-kar) and dry (Khosk-e-kar) sections of Qanat. The height of dam is as tall as the well depth, its width is as long as the well diameter and its thickness is 1 m. Seven orifices with 30 cm diameter are located every one meter started from the ceiling of tunnel upward (see Figure 2). The Qanat tunnel passes through the lower end of dam and the seventh orifice is seven meters above the tunnel crest. Figures 3 and 4 are illustrative of this hydraulic structure.

The main path way and all orifices are blocked from Nov. 20th to Apr. 20th every year. It was observed that the water level raises beyond the dam some where above the highest orifice every year. Later on, in Apr. 20th, the first highest orifice is reopened and let the first part of stored water depleted for irrigation. Each orifice is reopened every ten days and eventually all stored water will be depleted Finally, the main tunnel orifice is reopened on Jun 20th. This date is very important from wheat growth point of view. because this date fells on the irrigated wheat crop blooming stage on which a full irrigation is needed.

Table 1. Some of properties of Vazvan Qanat

Factors	**Amounts**
Length (m)	1800
Number of wells	72
Distance of wells (m)	25
Location of underground dam	Well number 40 from appearance of Qanat
Irrigated area (hec)	300
Discharge (l/s)	300
Height of tunnel ceiling (m)	7
Height of mother well	12.5

(A) (B)

Figure 2. Illustrative of orifices on underground dam (A) and tunnel (B) of Vazvan Qanat

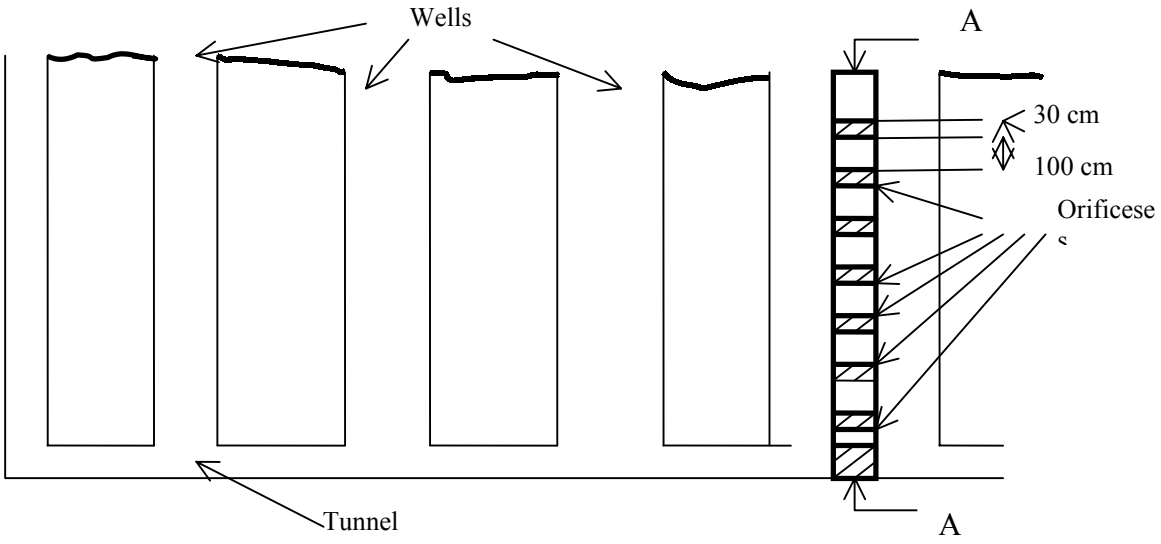

Figure 3. Structure of under ground dam built in Vazvan Qanat, Isfahan

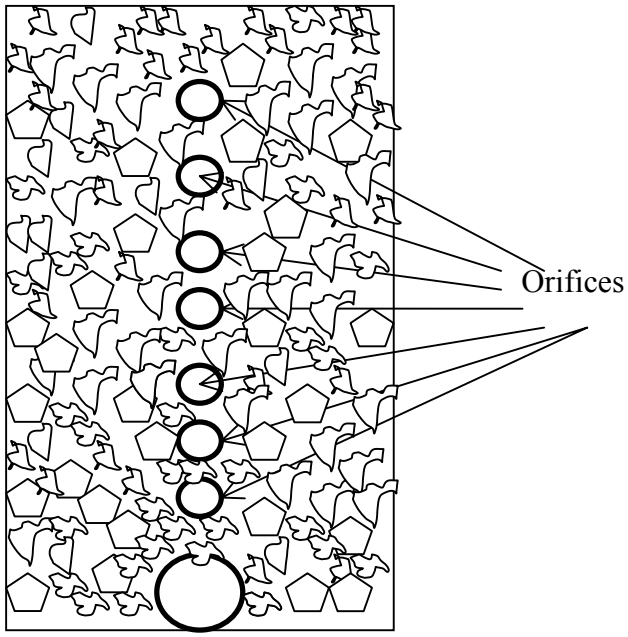

Figure 4. Section A-A as depicted in Figure 2

In this date the dam discharge is quite enough to supply this amount of water for wheat irrigation (Behnia, 1988).

Vazvan Qanat is still working, but, some parts have collapsed due to many reasons over time. These parts are repairing as shown in a video film report by Jahad-e-Keshavarzi of Borkhar and Mimeh, Isfahan (2006). They are constructing a second ceiling on the tunnel and put new covers on shafts to protect gallery from unpredicted risks (see Figure 5).

Figure 5 Second ceiling of Vazvan Qanat under construction

4. CONCLUSIONS

The following results are derived from this study:

1- The Qanat technology was invented and developed in Iran and extended to other countries in the East and the West passing of time.

2- There are still a large number of Qanats still working. Among these some are specific from point of view of mother well, length, rate of flow, oldness and attractiveness. Keikhosrow Qanat in Gonabad has the deepest mother well, one of the Yazd Qanats has the largest tunnel length and the most flow rate Qanat is Payekam Qanat in Bam. From innovation and talent point of view, Moon Qanat in Ardestan has a tunnel with two parallel floors and Vazvan Qanat has an underground dam to store water in non agricultural seasons.

3- Although the advantages of Qanat are numerous but renewing the idle Qanats for over seams to be a dream. This is due to sharply falling water level table takes place every year and every where due to rainfall scarcity and huge number of dug wells.

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