***[start slide]

Differences between Persian qanats and Roman aqueducts

In some publications Persian qanats are considered as the predecessors of Roman aqueducts.
And both ancient water delivery systems have many things **in common** like

- The transport of water over long distances (5 - 75 km)
- Mainly subterranean
- The use of channels with typical dimensions: about 0.6m wide and 1.2m high

But if we go into details, I think there are more differences than similarities.
***[overview]

- Even before this audience I start with a short **general introduction on Roman aqueducts** - and please let me know when I do not present the right facts.
- After that I will do the **same with Persian qanats** - this is not a new item for the Frontinus Gesellschaft, given the meeting in 2003 in Walfferdange (Luxembourg).
- After that I will make **a comparison**.

As you will understand my descriptions are in very **general terms**; both subjects bear much more aspects than I can describe now in this context.

Roman aqueducts
An **aqueduct** is *a channel or pipe-line to transport water over a greater distance, from a water source to its destination: often a city, sometimes a farm, industry or mill; there the water is distributed*.
***[Basic elements]

It starts with a **need** for extra water in a city, supplementary to other water sources like a river, rainwater catchment, wells, and/or springs.
Then a decision is made to finance and build the aqueduct by means of a masonry channel or terracotta pipes.
But first a suitable water source must be found, not too far away, at the right level and with water of good quality.

A (military) **surveyor** starts his work with adequate tools, looking for a good course of the aqueduct following the contour lines, with a more or less constant gradient downwards. The **construction work** of the channel or pipe-line is done - sometimes by the army - preferably in a trench just under the earth surface, with **as few works of art** as possible.
The water is conveyed in the channel or pipe-line based on gravity.
The result is that up to 80% of an Roman aqueduct is subsurface and the remaining **20%** are bridges, arcades etc. Some of these are still visible in the landscape, like bridges (PdG), arcades (Rome) and tunnels (Cave de Curé, France).
***[tunnel, bridges, arcade]

When the aqueduct shows up near the city a water **distribution system** is built by means of primary and secondary castella (distribution basins); the water is brought mainly to public street side fountains, a nymphaeum and bath houses, sometimes also to selected private persons (the local elite), mainly connected by lead pipes.
***[users].

Some bigger farmers in the countryside had their **own** aqueduct for irrigation or tapped (legally or not-legally) a main aqueduct nearby.

An aqueduct was **owned by** the local government or the town council; the construction of the aqueduct was often **paid** by a Maecenas. Construction was done by contractors with sometimes support from the Emperor and/or the Army by skilled slaves and non-skilled prisoners.

The Roman **empire** had almost a time span of 800 years: from 300 BCE to 400 CE, and was quite extensive: from England to Syria and from Hungary to Libya.
***[Roman empire]

So was the **distribution** of their aqueducts. Total known aqueducts is in between 1.000 – 1.500.
***[1500 aqueducts]

So the main **characteristics** are:
close to the surface, pipes (often of Greek origin) or channels (0,60 x 1,2 m), works of art, public ownership, for public use (fountains and bath houses)

Persian qanats
As you can imagine: in an arid country like Iran, water is **thàt** important for society!!
And not only for Iran.
But how do you get the water where you want it to be?

The term **qanat** came from an ancient Semitic word meaning "to dig".
It describes:

a combination of an infiltration gallery that collects water from an aquifer, and an underground tunnel, connecting a series of vertical shafts, to transport water by gravity to the surface for direct consumption and / or irrigation.
***[basic elements]

Its function is to exploit a certain **aquifer** which is a water bearing subterranean layer. There are thousands of these aquifers around the world, like under the Sahara desert, the Negev, Ma'an in Jordan and the Syrian desert and elsewhere.

An qanat starts with a so-called **mother well**; then it conveys the water to villages and towns in desert area's at distances of 5 - 75 km.

In arid climates qanats can easily be identified on aerial photos as **lines of craters** formed by the deposition of excavated materials around the vertical shafts.
***[from the air] ***[channel & shafts]

Construction is done by specialists in small groups with a special type of hierarchy. First the location of the mother well has to be established, later on the actual work was done, starting at the lower end. The know-how of the construction work was often transferred from father to son.
***[construction]

Qanats may reach a depth up to 100 m at the 'mother well' and a spacing of the shafts of 50 – 100 m apart.
The actual channel is about 0.60 m wide and 1.2 – 1.5 m high, in which water is flowing free from the 'mother well' to its destination.

The qanats represent often the **main and only water source** for hundreds or even thousands of persons in remote villages but also for oasis cities and major towns.
In Iran about 22.000 qanats were operational with a total length of 250.000 km.

Some 60 years ago **Tehran** was almost completely dependent of a series of qanats for its drinking water, till the advent of motorized deep pumps and the construction of dams.
***[distri 1,2,3 Europe 1,2]

The **first qanats** were constructed in the Iranian plateau probably 800 BCE during mining operations in NW Persia. The qanat was spread subsequently to other areas, in China, Arabia, around the Mediterranean and they bear quite different names.
***[distri WW]

The **main use** of qanats is for drinking water and irrigation.
***[users]

Many villages are equipped with small scale water **storage** sites where people can draw their water for drinking and household. Many qanat water is used for irrigating the land.
***[storage]

There are elaborate systems how to divide the irrigation water in time and volume – using sluices, general and local laws, surveillance people, time sharing systems and alike.

The **ownership** of rural qanats is a quite complex affair: in many cases a group of families of farmers owns the qanat and so the water. In general qanats have 10 – 250 owners and together they have to settle regulations how to manage the qanat.

Often qanats are constructed by ancestors hundred years ago and the rights are inherited from generation to generation. As you can imagine these qanats are the lifelines of the village and any disturbance can harm the fragile balance of life in deserted areas. That is why there are so many **special rules and regulations** about the maintenance of such vital utilities.

Because of their subterranean nature, there are **not that much works of art** attached to qanats, although there are **a few qanat bridges** known like the one in Kharanaq in the Yazd province of Iran.
Some qanats are (or were) even equipped with underground **dams or water mills**!
On the other hand: qanat water is still in use for **cooling** of major buildings and even ice storage sites.
***[works of art]

Comparison

For those who are mixed up now by all this information about 'what is what' in underground water structures, we present a comparison, based on three issues:

- Physical Geography
- Technology
- Societal

***[see the next three slides]

	Element	Persian qanat	Roman aqueduct
	Physical Geography		
1a.	Character of the terrain	Alluvial fans in mountainous area's	From mountainous to almost flat area's
1b.	Climate	Mainly in arid regions	Semi-arid and wet area's
1c.	**Source**	Mother well(s) in an aquifer	Spring. river, lake; by exception well or aquifer
1d.	Type of source	Delayed delivery	Instant delivery (spring, river)
1e.	Place in the landscape	100% subterranean	Some 20% above surface
	Technology		
2a.	Construction	Subterranean channel with shafts every 25 - 75 m	Masonry channel or pipes, close to the surface, sometimes manholes every 35 - 70 m
2b.	Builders	Paid specialists, professionals	Slave specialists, contractors, sometimes military personnel
2c.	**Course**	(Almost) straight line	Sinuous, following the contour lines
2d.	Works of Art	No, by exception subterranean dams and mills; chilled water used for cooling	Bridges, tunnels, arcades, siphons, distribution stations
2e.	Distribution	Sluice gates, open channels; timesharing; use of clepsydra, sundial, stars	Castellae divisoria plus lead or ceramic pipes
2.f	Storage	Only local, in modest volumes	No, only behind some large bath houses in Rome
2.g	Surplus water	Wasted or reused in other qanats at lower level	Flushing sewers and public toilets, fullers
	Societal		
3a.	**Users**	Irrigation and public. By exception (for cooling) in private housing	Public and bathhouses. But also to some degree industry, private individuals, farmers
3b.	**Ownership**	In cooperation (10 - 250 stakeholders / farmers). Sometimes rich individual / landlord	Public body, town council
3c.	Finance	Members of the cooperation (by exception a private investor)	Local Maecenas, emperor, town council
3d.	**Status within society**	The only water source, essential for life, utilitarian	Additional to existing water sources, luxery (baths, nymphaea), showcase of pride and power
3e.	Present status	Many still in use	Almost all out of use; some reconstructed

	Basics		
	Numbers	33.000 (in Iran 2001)	1.500 (in total)
	Cross-section	0,6 x 1,2m	0,6 x 1,2m
	Typical length	20 km	20 km
	Typical discharge	2.000 m3/d	20.000 m3/d
	Typical depth	10 - 50m	5m
	Typical fall	0,07 - 0,1 %	0,1 - 0,5 %

My conclusions
***[conclusions]

Although there are some similarities, qanats are quite different from roman aqueducts

Most striking:
- The difference in the sources: internally versus externally
- The almost straight line of a qanat and not sinuous like an aqueduct
- Qanat(s) are often the only source of water in a community; the aqueduct water was often additionally to other sources
- Almost all Roman aqueducts are out of use, many aqueducts are still in use

Why is this important
- There is too much misunderstanding and misuse of the word qanat
- How about the so-called 'qanats' in Europe, like those in Madrid, Sicily, Walfferdange? This is one of my present research topics at home.

Problems?
The story of Nonius Datus and the aqueduct tunnel in the area of Saldae is quite known here: without his help the city should have owned even two tunnels in one hill.

But even today - in the realm of the Persian qanats - stupid things occur, like the next slide shows.

***[problems]

Thank you.

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Frontinus Gesellschaft