Encyclopedia of Vernacular Architecture of the World

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Volume 1 Theories and Principles
  Approaches and Concepts
  Culture Traits and Attributes
  Environment
  Materials and Building Resources
  Production
  Services
  Symbolism and Decoration
  Typologies
  Uses and Functions
through shading of canals. Transportation by canals was once dominated by barges drawn mostly by horses on towpaths that ran parallel to the canal, lending the characteristic two-tiered section.

Canal systems in flat settings in which there are minimal changes in elevation are not required to provide vertical lifting of craft. Water supply is ample and occasionally tidal. Given the linear nature of the waterways, settlement forms are different since they can be laced into networks of canals.

As density of development increases along canals, scattered individual buildings form a continuous edge along the waterfront with each building requiring some frontage. If the canal is the dominant mode of transportation, as in Venice, or if pedestrian and vehicular access run next to the canal, as in the Canal du Midi, France, then the character of the canal is public with buildings fronting the canal. If the other modes of access run perpendicular or parallel but removed from the canal, the service and utilitarian nature of the canal is reinforced with buildings 'backing the canal', such as in Suzhou and Zhubiaojia, China (Chow).

Growth and extension away from the canal occur both perpendicular and parallel to the canal. In the example of the Venetian lagoons, frontage on the canal is critical since the canal serves as the dominant means of access. Lots are narrow along the canal but run quite deep into the backland. Secondary means of movement (calli) run between the lots from the canal to the next waterway (Goj). In Chinese villages around Shanghai, the canal is predominantly utilitarian in purpose with a pedestrian network that runs independently of the canal. In Zhubiaojia, the pedestrian street runs parallel to the canal, but one room's depth away. The pattern of settlement focuses on the pedestrian street, one side bordered by one-room deep houses which have access to the canal, the other side bordered by the more typical Chinese courtyard fabric, narrow lots with common walls at lot-lines and a series of courtyards and buildings within the depth of each lot (Chow).

RENÉE CHOW and THOMAS CHASTAIN

At the beginning of the 11th century Granada became the capital city of a small Islamic kingdom, after the Cordoba caliphate disappeared and al-Andalus split up. The city was provided with a complex water supply system. Water came from springs as well as from two rivers close to urban settlement, the Genil and the Darro, and flowed through open channels, dug out of the soil without masonry works, until it reached the city walls. The ravines were crossed with small aqueducts. The most important of these channels is the Acueduct of Aynadamar (Sâṣiṣat 'Aṣr al-Damâ'), that carried water from Fuente Grande, located at Alfacar about 10 km (6 mi) north of Granada, down to the highest city districts of Albayzin and old Alazaba.

After entering the urban enclosure, channels went underground, being built with bricks and slabs of stone. Then they branched out through a set of pipes made with short ceramic tubes (atmâs). In this way, water was delivered to public cisterns as well as private ones, and large earthen jars; it was also brought to gardens and orchards. The perfect design of this complex distribution and storage net of drinking water allowed it to work continuously from the 11th century until the 1950s. The high number of public cisterns let families have access to water at an average distance of less than 100 m (330 ft) from their houses.

Although nowadays the system has fallen from use, there are still 26 Islamic cisterns in good condition in Granada. According to their effective capacity to store water, they can be divided into three groups: the largest are the three whose capacity is over 150 cu m (5300 cu ft); five are of medium size, storing between 50 cu m (1765 cu ft) and 150 cu m (5300 cu ft); the 20 small ones can store less than 50 cu m (1765 cu ft). Five have several naves, separated by solid brick pillars, whereas the remaining 23 have only one nave. Their walls were built with rammed soil and lime concrete (tapiol), or bricks, but vaults were always made with bricks – barrel vaults with semicircular, pointed, or keel-shaped sections, groined and cloister corner vaults, or a dome. Although these vaults are usually under-

Water Supply

1.6.5 a–i Canal cistern (Granada)

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Introduction to the cistern at Aljibe de las Tomasas, Granada, Spain.
ground or are used as basements of houses, some emerge above the pavement level of streets and squares. Vaults and walls of cisterns were covered with reddish lime-plaster in order to make them waterproof. Their pavements were made with the same plaster or using floor ceramic tiles. The main facades of the cisterns were often monumental, having huge horseshoe arches decorated with glazed tiles.

Among the type of cistern with several naves, possibly the most interesting one is Aljibe de las Tomaseas, located near the nuns’ convent of Santo Tomas de Villanueva. It has a nearly square ground plan, 6.6 x 6.5 m (22 x 21 ft) and a height of 4.5 m (15 ft), with four pillars that support groined vaults. It can store 154 cu m (5438 cu ft) of water. It is supposed to have been built in the 11th to 12th centuries.

The most well-known cistern with only one nave is Aljibe de Trillo located, like the former, in the enclosure of old Alezaba. It measures 5 x 3.5 m (17 x 11 ft) and is 5.25 m (17 ft) high. Its capacity is 50 cu m (1765 cu ft). It is divided into two sections, the first covered with a cloister corner and groined vaults, and the second one with a huge barrel vault. It has a fine horseshoe brick arch in the main facade. It was built in the 14th century, the period when nazarid architecture flourished most.

ANTONIO ORIHUELA

1.6.5.6 Channel: falaj

During the past centuries complex systems of cultivation were constructed in the oases, wadis and mountain terraces of the Arabian peninsula. The sweet-water available from springs, deep wells or winter rains was carefully collected and guided to the fields, oasis or simply a palm tree.

The existence of many towns and villages in Arabia was solely dependent on the availability of water and the means of transporting it into the fertile lands. Permanent or even temporary drying of the water channel (falaj) owing to shortage or drought would cause the crops to die and often the migration or even death of the village inhabitants. In many cases the falaj has been the cause of the rise and fall of towns and villages in the Arabian peninsula throughout the centuries.

Land surrounding the village was sculpted to yield the maximum possible harvest. In the mountains, where slopes were terraced with stone walls which supported the fields, water was led in little channels from the hillsides above or along the cliffs of deep wadis on cleverly constructed ledges. Water channels were dug underground as well. The complex falaj systems of the Hajar mountains of Oman and the United Arab Emirates and the qanat of Bahrain, brought water from its source at the foot of the mountains or the highlands, through underground tunnels to the fields.

The length of the falaj varied from a few hundred metres to many kilometres. Its width and depth depended on the quantity of available water, the terrain it travelled through, the geographical location and the type of ground. The width varied from 20 cm (8 in) to 100 cm (40 in) and the depth from 30 cm (12 in) to several metres.

Similar in its function to the qanat in Iran, the falaj carried water from natural water sources and reservoirs into the fields for cultivation and for human and animal consumption. The main difference between the qanat and falaj is in the nature and depth of the channel. Falaj usually run in an open channel – with a few exceptions where tunnels are dug to avoid the need for a longer length when a barrier is reached. In principle the qanat is an underground tunnel; when it surfaces the water is then distributed by the qanat in a similar way to the falaj.

The most critical element of the system is its slope which has to be very carefully graded. It is not known whether there were any actual mathematical calculations used in the construction of the falaj, other than taking into consideration the shortest practical route, the terrain, the geology, the distance travelled and the level difference between the source and the farm. The calculation principle was both to facilitate the movement of water and control its rate. The ideal gradient was one which neither allowed the water to run so quickly that its force would wash away the sides of the falaj nor so slowly as to become stagnant.

It is not unusual to find an oasis with several levels of falaj running in different directions to the various fields. The falaj is still very much in use today and is maintained by one or more farmers depending on the size of the falaj system. However, all the farmers of the village are responsible for the day-to-day watering of their own crops and for any major repair works.

DARIUSH ZANDI

See also for 1.6.5.6

Z. IV.5.6 B Andalucian

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