

The construction technology of Chinese ancient city drainage facilities

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Abstract: In ancient China, according to the local natural environment, a variety of drainage facilities were built in order to excrete rainwater, domestic sewage, production wastewater and so on. These drainage facilities were mainly made of pottery, bricks, wood, stone, etc. For example, ceramic water pipelines, buried in the ground, connect together one by one, and there was a slight drop from one end to the other in favor of drainage. These measures can also be used for reference in today's urban drainage and flood control.

1. Introduction

Drainage is an important part of urban construction, and closely related to people's lives. In ancient cities in China, according to the local natural environment, a variety of drainage facilities were built in order to excrete rainwater, domestic sewage, production wastewater and so on. These are important contents in the study of ancient cities of China, and they can also be used for reference in today's urban drainage and flood control.

2. Urban drainage facilities and construction techniques during Xia and Shang Dynasties

With the birth of cities in China, urban drainage was paid attention to, and the corresponding facilities were built. As early as 4000 years ago, one ceramic drainage pipeline had appeared in Henan Huaiyang Pingliangtai Longshan culture site. Located under the south gateway with a depth of 0.3m, the pipeline is over 6 meters long, and consists of three earthenware pipes, two of which are on the top, one on the bottom. Per pipe is 0.35~0.45m long, and one end with a diameter of 0.27~0.32m is thicker than the other end with a diameter of 0.23~0.26m. Each thinner end faces south, inserting in a thicker mouth of another pipe. From the whole pipeline, the north part is slightly higher than the south one in order to be suitable to drain smoothly ^[1](fig.1).



Figure 1. drainage pipeline

What is more, other drainage pipelines have been found inside the capital of Xia Dynasty named Erlitou site. For example, two underground ceramic pipelines have been excavated in the second



courtyard. The first is located at the northeast of the courtyard, which passes through the east corridor and the east wall. It consists of eleven earthenware pipes which existing length is about 7 meters and its west end is higher than the east one in order to be easy to discharge the courtyard water. Before burying and installing these pipes, one trench must be dug and then covered with soil. The second pipeline, which is located in the southeast of the courtyard, at first runs along the east corridor, then turn to the east when it is 4.1 meters away from the inter corridor of the south wall, passing through the fourth gate of the east wall. It is an underground square cavity built from the top to bottom of the stone slab, and it is covered with soil for walking. The north and south part of the cavity is more narrow, but the east and west part gradually becomes wider^[2].

During Shang dynasty, one drainage ditch has been excavated outside the west wall of Henan Yanshi Shang city. The ditch cross section is in the form of upside down trapezoid with the mouth width of 2.2, base width of 1.35, height of 1.5 meters. In the middle of the ditch is the stone channel with a width of about 0.4 and a depth of about 0.6 meters. At the bottom of the trench is red brown rammed earth, and paving a layer of flat stone as the bottom stone which left and right sides are four-story stone walls. The top of the ditch is stone slab which both sides are covered on the stone walls. The bottom of the channel cavity is one layer of flat stones, the cavity walls consist of four storey stone, on which is capping stones. Between the channel wall and trench fills smaller stones.

In the autumn of 1972, two ceramic pipes of Shang Dynasty at Anyang Yin Ruins, buried in the ground with a depth of 1.1 meters, is in the form of “T” from north-south to east-west. Among them, the section from south to north remains 7.9 meters long, consisting of 17 ceramic pipes; the section from east to west, 4.62 meters long, 11 ceramic pipes, the west end being higher than east one. Both are connected by one three-way pipe^[3](fig.2).

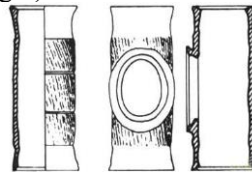


Figure 2. three-way pipe

3. Urban drainage facilities and construction techniques from Warring States to Han Dynasty

In Handan, the capital of Zhao state of the Warring States period, one rammed earth wall was excavated in 1970. The cross section of the rammed earth wall is in the shape of a step. In the inside of the wall, some ceramic draining tanks have been found, its cross section being concave. There are two "top noses" with one width of 6~7cm at the slight wide end. Accordingly, the installation program is to pit the trench at first, and then place some ceramic draining tanks at the trench bottom, connected together with these "top noses". A total of five draining tanks have been cleared, and their channel shapes were basically the same. They were all laid on the inner slope of the city wall. From their position and trend, the drainage channels should extend from the base of the wall to the top. There may be a rain proof built at the top of the wall in order to drain rainwater downward into the trough. the distance between these tanks is from 15m to 27m^[4].

In the Chang'an City Changluo palace of Han dynasty, a complete set of drainage facilities have been found to the north of No. 6 building site construction platform. The drainage system consists of two sedimentation tanks and a number of circular or pentagon drainage pipes. Two sedimentation tanks are located in the two courtyards respectively, and connect together by pipelines. At that time, the rainwater from the roof first flowed into the sedimentation tank in the courtyard, and after the debris was precipitated, the clear water was finally discharged out from the building through the underground double pipes. This could ensure that the drainage pipe would not be blocked, and only need to clean up the settling tank regularly (fig.3).



Figure 3. sedimentation tank

4. Drainage facilities and construction techniques in Tang, Song and Ming Dynasty

In 2009, to the south of Daming palace Xuanwu gate of Tang dynasty Changan city, one water culvert relic has been found. The culvert was made of bricks and stone, with one length of 2.86m from east to west, one width of 1.06m from south to north, one height of 0.7m, and one internal width of 0.62m. The bottom and sides of the culvert were built with slates, in which the bottom stones were evenly chiseled with four rhombus holes. Nowadays, there is one surviving stone cover at the top of the culvert, and there are four rhombus holes at the bottom surface, just corresponding to the hole of the bottom stone. Accordingly, there should have been a stone cover on the top of the east side. In addition, 4 rows of side bricks were arranged from north to south outside the west end, and slope from west to east. So water flowed from the west to the east^[5] (fig.4).



Figure 4. water culvert

At the same time, the drainage culvert has also been found in the West Garden of Daming Palace. It was made of bricks and stone, and in order to prevent blockages, two iron windows have been installed. The first is mullioned window consisting of iron bars for blocking larger garbage. The second consists of iron bars which form many rhombus holes for blocking smaller garbage to ensure the smooth drainage (fig.5).



Figure 5. iron window

In 2004, a wooden canal site of Southern Song Dynasty was excavated in Changsha city of Hunan province. In terms of architectural form, it consists of two parts from west to east, such as triangular wooden building and trench wooden building. Before building the triangular wooden building, dig a deep groove with a width of 2.8m and a depth of 1.2m. The north and south sides of the groove are

vertical and the bottom is smooth. At the bottom of the ditch 58 wooden floor plates are paved, and its west end is 0.3m higher than east end, forming a slight slope. The floor plate is rectangle with a length of 2.5m, a width of 0.65m, and a depth of 0.15m. Along the both side of the plate, two deep grooves were chiseled with a width of 0.5m, a depth of 0.03m. Some tilted plates were erected in turn on the grooves. The tilted plates are made of 1/3 of the log, usually 1.6m in length, 0.66 in width, 0.2m in depth (fig.6). On the east side of the triangular drainage facilities are wooden trench buildings consisting of two wooden grooves from north to south, named No.1 and No.2 in turn. Their construction method is to dig a trench with a depth of 0.65m and a width of 2.1m on the ground at first, and then erect wooden blocks and vertical symmetrical stakes on both sides of the east and west of the trench, with some vertical symmetrical stakes on both sides of the blocks. Among them, in the No.1 groove are mainly round stakes, in the No.2 mainly square stakes. Between the lower ends of two stakes, sometimes a strip of wood with square or rhombic mortises is paved in order to sustain.



Figure 6. drainage facilities

About Ming Dynasty City, We can take Liaosi old city of Hunan province as the representative of all. At the palace area retains the stairs, walls, wall, apron, drainage and other architectural ruins. In the center of the road, the smallest pebble was arranged in the shape of herringbone pattern, and some large pebbles were paved at both sides of the road for slope protection and drainage ditch^[6] (fig.7).



Figure 7. drainage ditch

5. Summary

Ancient Chinese urban drainage facilities are mostly made of pottery, bricks, wood, stone, etc, mostly buried under the ground. In order to facilitate drainage, waterways tend to have slight slopes. Most of these facilities are well preserved, and they are important contents for the protection and development of ancient cities. These measures can also be used for reference in today's urban drainage and flood control.

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