Research on the Structure and Construction Technology of Longshou Canal Engineering in the Western Han Dynasty

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Abstract: In order to clarify the characteristics and causes of engineering structure and construction technology in ancient hydraulic conservancy projects in Guanzhong area, taking Longshou Canal in the Western Han Dynasty as the research object, the hydrogeological environment of Longshou Canal construction was analyzed by means of literature method, interview method and field investigation method, the components and functions of Longshou Canal engineering structure were studied, and the "well canal method" used in the construction process of Longshou Canal was studied and discussed from the aspects of channel selection and shaft location determination method, and the digital model of Longshou Dam was established by using three-dimensional modeling software. Use Unity3D software to build a digital display platform for Longshouba virtual scene. It proves the engineering structure concept and construction process of Longshou Canal Project that conforms to nature, leads nature and uses nature. It provides a useful reference for inheriting and carrying forward the advanced technology in ancient water conservancy construction technology, studying the construction technology of ancient water conservancy projects in Guanzhong area, and providing new ideas for the digital display and protection of ancient water conservancy cultural heritage.

Keywords: Western Han Longshou Channel; Engineering Structures; Construction Process; Unity3D

1 Introduction

China is an agricultural country and has attached great importance to water conservancy development since ancient times. Ancient water conservancy engineering technology is at the world's leading level [1], and water conservancy projects built by successive dynasties still play an important role today. Ancient water conservancy projects have endured for a long time and have historical and cultural value, water conservancy engineering value and construction technology value. At present, scholars have carried out research on ancient water conservancy projects, mainly focusing on the historical and cultural values and the value of ancient water conservancy projects, exploring the connection between ancient water conservancy projects and politics,

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economy and culture, and talking about the protection strategies of ancient water conservancy projects, for example: Yu Guangjie [2] (2017) starts from the cultural characteristics of different periods and analyzes the naming characteristics of ancient water conservancy projects in China; Chaogenchi[3] (2016) analyzes the impact of climate change on the distribution of ancient agricultural water conservancy projects from the perspective of climate. Ren Yajun [4] (2019) took Zheng Guoqu as an example and proposed protection strategies such as green protection, cultural guidance, and hierarchical management. Liu Jianzhe [5] (2020) based on the History of Ancient Chinese Irrigation Engineering Technology to make a brief analysis of China's water conservancy history, culture and future development inheritance; For example, Wang Deyao et al. [6] (2021) compared the Dujiangyan and Zhengguoqu water conservancy projects from the perspectives of natural conditions, hydraulic engineering components, and building materials; Zheng Hongchun [7] (1996) briefly discusses the engineering techniques of Zhengguoqu, Baiqu and Longshou canals.

However, there are few related studies on the construction process of Longshou Canal, so it is necessary to further discuss the construction process of Longshou Canal, analyze the hydrogeological environment of Longshou Canal, understand the engineering structure of Longshou Canal, and discuss the construction technology of Longshou Canal.

2 Analysis of hydrogeological environment of Longshou canal construction

2.1 Hydrological characterization analysis

The site of Longshou Canal needs to cross the loess plateau from south to north - Shangyan Mountain, most of which are multi-level terraces running east-west, the whole terrain is high in the north and low in the south, wide in the east and narrow in the west, showing an irregular triangle. After a long period of rainfall, many north-south ravines have been formed..

Long-term erosion and rainwater erosion by the Luo River, more ravines are formed on the sides of the valley on both sides, mostly in the shape of "V", and various ladder table structures are formed on the plateau, and there are many erosion depressions, structural depressions and low-gentle hill hills of different sizes [8], which is beneficial to avoid loess collapse during the construction of Longshou nullah.

Shangyanshan climate belongs to warm temperate semi-humid, semi-arid monsoon climate, precipitation of 514mm, under the influence of geological structure and climate, river infiltration, underwater infiltration on the loess layer and rainwater infiltration promote Shangyanshan groundwater storage abundant, which is unfavorable to the construction of Longshou canal culvert.

2.2 Geological characteristics analysis

The landform of Shangyan Mountain belongs to the loess plateau, which is a soil-like accumulation with a particle size between 0.005mm and 0.05mm, and is a yellow silty soil with porous columnar joints. Loess soil is relatively loose and hard when dry, but after erosion by river water, the structure is easily damaged, causing the basement to collapse [9]. Due to the influence

of the nature and structure of loess, loess will form loess erosion landforms after erosion of surface water and groundwater, including loess collapse, loess mudflow, etc. [10].

The easy collapse of the loess of Shangyan Mountain was the main problem encountered by Longshou Canal when passing through Shangyan Mountain. In repeated construction practices, Han laborers created the "well and canal method", which has reference value for solving the problem of water shortage in arid areas.

3 Longshou canal engineering structure research

Longshou Canal is composed of three parts: shaft, culvert and open channel, of which the shaft and culvert are the core parts of Longshou Canal, as shown in Figure 1.

3.1 Shaft

The shaft is the first step in the construction of the Longshou canal and begins with the culvert at the time of construction. The shaft is about 1 meter wide and more than 90 meters high, and the height changes according to the local terrain, which plays the role of ventilation and excavation. When sinking the well, cymbal, milling, chiseling, hammer and other tools are used to dig down in the determined position, and as the wellbore continues to deepen, it is necessary to manually remove stagnant water, etc., in order to prevent silt from blocking the wellbore, bricks, ceramic well rings, etc. will be used to strengthen the well wall.

3.2 Culverts

The culvert was excavated in the opposite direction from the inlets and outlets at the north and south ends of the mountain during construction, with a length of more than 5,000 meters, and due to the excavation of the shaft, the culvert was divided into several segments. When the excavation of the shaft reaches the corresponding depth, the construction of the culvert becomes the opposite excavation between the various sections, which can initially solve the problems of lighting and ventilation during the construction of the culvert and improve the safety of the culvert, as shown in Figure 2.

3.3 Nullah.

The nullah is basically the same as the general channel, and the channel connecting the two ends of Shangyan Mountain with the culvert is the nullah. The nullah and the culvert are basically at the same level, and Luoshui enters the culvert inlet through the nullah at the north end of Shangyan Mountain to circulate the entire culvert, and flows into the nullah at the southern end of the mountain from the outlet of the culvert to xirrigate the fields around Pucheng and Dali, Shaanxi Province.

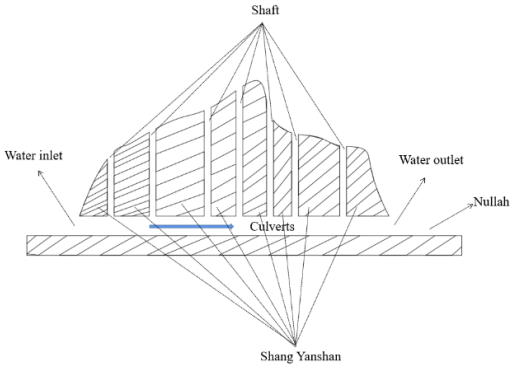

Fig. 1. Structure diagram of Longshou canal well canal method

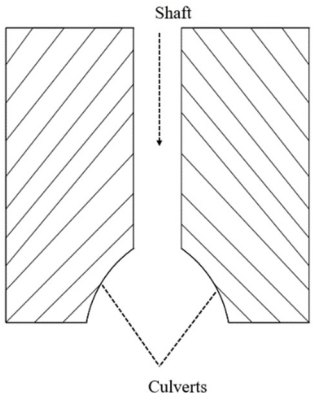

Fig. 2. Cross-sectional view of Longshou canal shaft and culvert

4 Discussion on the construction technology of Longshou Canal

Longshou Canal is the first underground water canal in China's history, and the "well canal method" pioneered has a reference effect on the development of water conservancy in modern arid areas, and needs to be explored from all aspects. In Longshou canal engineering technology, the selection of channels and the measurement of height difference are crucial, and the selection of channels will affect the difficulty of construction, the consumption of manpower, material resources, financial resources and the success rate of Longshouqu project. If the height difference is not accurately measured, it will affect the location of the outlet of the culvert, the height of the shaft, and the deviation of the culvert channel will also occur. Therefore, in the discussion of the construction technology of Longshou Canal, the selection of Longshou Channel and the determination method of shaft depth are mainly discussed, among which the local terrain height difference of Shangyanshan needs to be measured in the determination of shaft depth.

4.1 Selection of Longshou channel

Shang Yan Mountain presents an irregular triangle as a whole, with different widths and narrow faces, which has a great impact on the selection of a suitable canal line. According to the analysis of the Longshou canal site, the canal line of Longshou canal runs northwest and southeast, which is the narrowest place in Shangyan Mountain. This canal line is basically the same as the canal line of today's Luohui Canal, indicating that the canal line chosen by the ancients is the most suitable canal line. First: the canal line is straight and close, which can save a lot of manpower, material resources and financial resources, and the soil of Shangyan Mountain is soft and easy to collapse, and reducing the distance of the canal line can improve the success rate of the construction project; Second: there are many ravines and caves here, which can be used between them through correction, reducing the amount of labor and improving the efficiency of construction projects; Third: from the perspective of topography, the north is high and the south is low, and the water flow can be smoothly introduced with the help of the terrain.

4.2 Method for determining shaft depth

The shaft is the first step in the construction of the Longshou canal project, and it is excavated almost at the same time as the tunnel, which can expand the construction surface on the one hand; On the other hand, it saves time. According to the geomorphological characteristics of Shangyan Mountain and the analysis of mountain trend, the depth of the shaft is not uniform. When determining the shaft depth, it is divided into the following steps:

1.Determine the location of the culvert mouth, which is a key step. The location of the canal mouth is affected by the following three factors: (1) the inlet and outlet of the culvert should be preliminarily determined by measuring the relative height of Shangyan Mountain; (2) The Luo River has a large sand content and is a seasonal river, which will increase the open channel bed during the high water period, decrease the river bed in the dry period, and change the position of the underpass inlet; (3) Longshou Canal adopts artesian water diversion according to the north high and south low of Shangyan Mountain, and the slope of the underdrain channel needs to be considered, the slope is over the large river turbulent, which is easy to cause the channel to collapse, the slope is too slow for the small river, and the sediment is easy to block the channel. Therefore, the above three factors are comprehensively considered to finally determine the location of the canal mouth.

2. Determine the well spacing and location of the shaft. The well spacing and location of the shaft were determined by measuring the horizontal distance of Shangyan Mountain. The shaft spacing and location are affected by the local topography of Shangyan Mountain, and the general law is that the terrain is higher and the well spacing is small. Smaller areas with larger well spacing. At present, 7 shafts have been found in the section of Longshou Canal Ruins Key Investigation between 2600 meters, and the adjacent wells are 11 meters, 160 meters and 224 meters apart.

3. Determine the depth of the first shaft. According to the position of the underpass channel, the position of the first shaft near the channel mouth is used as the first shaft, and the shortest distance can reduce the error. The first shaft was excavated to the same horizontal position as the mouth of the culvert, and the depth of the first shaft was used as a reference for the depth of other shafts.

4. Determine the depth of other shafts. Taking the depth of the first shaft H1 as a reference, the depth of other shafts was determined by measuring the local topography difference of Shangyan Mountain. Other shaft depths can be calculated according to geometric equation (1).

$$\Delta h1=h_2-h_1 \tag{1}$$

Then the second shaft depth h2 calculation formula is:

$$h2=h1+\Delta h1$$

Similarly, the formula for calculating the depth of the third shaft h3 is:

$$h3=h2+\Delta h2$$

By analogy, shaft depths such as h4, h5, h6, h7, etc. can be obtained, as shown in Figure 3.

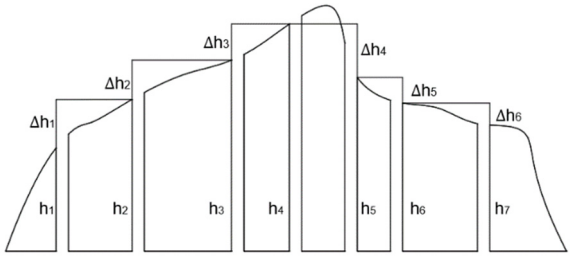

Fig. 3. Schematic diagram of the calculation method of the shaft depth of Longshou Canal

5 Digital display of virtual scenes

5.1 Longshou Dam model established

The Longshou Dam model is mainly constructed by 3D modeling software to construct the real scene of Longshou Dam. According to the collected image data and data of Longshou Dam-related buildings, combined with the drawn three views of Longshou Dam buildings, Rhinoceros and C4D (CINEMA4D) were used to model the Longshou Dam body building, which mainly includes houses, railings, drainage outlets, dikes, dams and other parts, as shown in Figure 4. The most important thing in the modeling process is to determine the scale relationship of each part of the model and the relevant structure of the dam body to ensure the authenticity of the 3D model of Longshou Dam.

5.2 Virtual scene simulation design

To simulate Longshouba buildings and regional terrain, the 3D model and the resulting texture assets are first imported into the Unity 3D software to generate Unity3D assets. Review the collected imagery to determine the architectural style of Longshou Dam and the style of the surrounding environment. Use the material module and texture to render the model, and solve the problem of material assignment by setting the basic color, diffuse map, normal map, bump map, etc. of the model in the scene.

Simulate the sky environment in Longshouba area, add sky resource packs, set lighting, etc., and switch between the day and night scenes. The simulation of the water surface effect in the Longshou Dam area uses Unity's plug-in KWS Water System to design the water surface effect, place the water resources in the corresponding scene position, adjust its height and area size to place the water resources in the corresponding scene position. The effect of the water surface can be achieved by adjusting the corresponding parameters. Adjust the transparency of water through Transparent, adjust the size of water ripples through Wind Speed, adjust the intensity of water surface light through Reflect Sunlight, etc. Restore the Longshou Dam scene to achieve the desired effect, so as to complete the design of the Longshou Dam digital scene, as shown in Figure5.

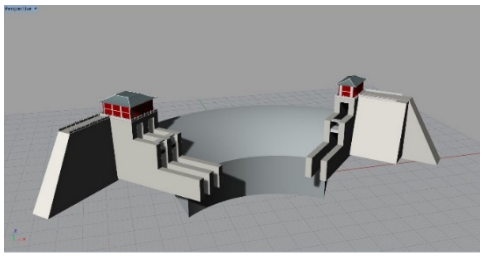

Fig.4. Schematic diagram of the digital model of Longshou Dam

Fig. 5. Longshou Dam virtual scene display view

6 Concluding remarks

Through the analysis of the hydrogeological environment of Longshou Canal, the engineering structure of Longshou Canal was understood and the construction process of Longshou Canal was discussed from multiple aspects, and it was found that Longshou Canal conforms to nature, leads nature and uses nature in construction, and correctly applies science and technology. The discussion of the ancient water conservancy project of Longshou Canal, from which the effective scientific methods were found and rationally used, continued to play a role in modern water conservancy engineering. The rational use of the "well and canal method" has brought important enlightenment and construction process guidance for the smooth construction of the modern water conservancy project "qanats" in the arid area of Xinjiang. The digital display platform of Longshouqu water conservancy cultural heritage was built by using virtual reality and other digital technologies, and the scene of Longshou Dam was highly restored by using three-dimen-

sional modeling technology, which made a useful attempt for the digital protection of Longshouqu water conservancy cultural heritage. Therefore, discussing and studying the construction technology of ancient water conservancy projects in Longshouqu in the Western Han Dynasty, and displaying them using digital technologies such as virtual reality, is not only a useful supplement to the research on the history of ancient water conservancy construction technology, but also a powerful promotion of modern water conservancy engineering construction technology, and also expands the influence of Longshou canal water conservancy culture dissemination and promotes the protection of Longshouqu water conservancy cultural heritage.

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