Research on Failure mechanism and Reinforcement Technology of Shangmaji Weir

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Abstract. After the reinforcement and repair of the Shangmaji weir in Wanyao Irrigation District of Jiangshan City in 2014, the results of the repair did not improve much. The surface layer of the weir fell off, these not only affected the drainage function of the weir, but also the appearance was different from what is now advocated "Green ecology" is incompatible. This paper analyzes the causes of damage to this problem, and obtains two solutions: drilling, grouting, vertical paving, and to extend the width of receiving water step. After adopting the research programme, the degree of shedding of pebbles is greatly reduced, and the strength of the weir is significantly increased.

1 Introduction

What people care most about whether the weir is reliable, durable, and whether it can fully play its role. For this phenomenon, many scholars at home and abroad have conducted in-depth studies on the repair and reinforcement of the weir. The rubber dam has a simple structure. The use of rubber dams to reinforce the stone dam is a common method, but it has some shortcomings. As time goes by, the rubber dam has serious leakage. For northern China, the water in the rubber dam freezes into ice in winter and needs to be broken., and maintenance is time-consuming and laborious[1]; the construction of permanent barrages to reinforce the dam body is also common, but this method has a long cycle and high input cost, and its effect is not very obvious[2]; for valley areas, the mud in the river bed Sand flow can cause damage to the dam body. Lowering the height of the silt dam is also a measure to protect the dam body. However, this method is only suitable for specific areas. For the barrage in plain areas, it is not practical[3]. A relatively primitive way to restore the dam body is to use the deep- rooted characteristics of plants to grow aquatic organisms to strengthen the dam body. This method is novel, but its cycle is relatively large. Plants need a cycle from planting to growth and rooting, and different water areas Plants that adapt to growth are also different, and they have very large uncertainties[4]; domestically, the method of strengthening the dam body is commonly used the method of punching and grabbing wells to backfill the clay anti-seepage technology. This technology has simple construction technology and easy quality control. The soil layer has high requirements for soil materials, and it is not suitable for strengthening earth-rock dams with larger rocks[5].

The above analysis shows that the damage situation of the dam body is different, and the solution measures are also different. Shangmaji Weir is located in Hecun Town, Jiangshan City, Zhejiang Province. The main material of the dam is made of concrete-filled masonry. The surface is made of cast-in-place concrete with a thickness of 1m. The surface is covered with pebbles. The water height is 0.46m, the drop platform is 1.6m, and the cross-sectional length of the dam is 9.4m. There are five steps in the overflow area of the Shangmaji Weir. Except for the top platform, the remaining four platforms all have damaged pits of different sizes. The pebbles on the surface are washed away, resulting in the continuous expansion of the gap area, exposing the concrete layer below; The same problem exists in the sand sluice area. The surface pebbles fall off, causing the entire step to be washed away, exposing the sand and gravel layer below, which not only causes soil erosion in the sand and gravel layer, but also endangers the block stone slope protection on the right bank. The situation will endanger the safety of residents on the shore. In response to the above problems, this article investigates and analyzes the damage mechanism of the weir, and gives a reasonable plan for reinforcement and repair to ensure the safety of the weir.

2 Damage Cause Analysis

2.1 Excessive water flow

The Shangmaji weir belongs to the Qiantang River system in Jiangshan City. The area of the Qiantang River system accounts for 91.3% of the total area of the city. Jiangshan Port is a first-level tributary of the upper reaches of the Qiantang River, with a total length of 134km, of which 105km in Jiangshan. It has the characteristics of short source and rapid flow, uneven distribution of precipitation from year to year, and large changes in flood and drought.

Jiangshan City belongs to the subtropical monsoon area, with four distinct seasons, sufficient sunshine, warm

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and humid, abundant rainfall, the multi-year average temperature is 17.1℃, the frost-free period is 253 days, the multi-year average rainfall is 1842.6mm, and the rainfall distribution is uneven. The rainfall from March to June is about It accounts for more than 57% of the total annual rainfall. It is prone to city-wide continuous rainstorms and heavy rainstorms, which can cause floods. After the rainy season, the precipitation decreases significantly, the temperature is high, the evaporation is large, and droughts are prone to occur in midsummer and early autumn, and are affected by typhoons during the period. External influences also often cause floods. The main stream of Jiangshan Port is a mountain river with large flood peaks. Floods often occur from May to July during the flood season. The floods rise and fall rapidly, and the time for water collection is short. The time from the maximum period of heavy rain to the peak of the flood is usually about 6 hours, it took 3-4 days. The maximum peak flow rate appeared in 1942 and was 4900 cubic meters per second; the maximum flow rate in five years was 1930 cubic meters per second.

It can be seen that the Shangmaji weir encounters a large water flow during the flood season every year. After many years of such erosion, the pebbles on the surface of the weir are easily damaged. As shown in Figure 1, although measures are taken every year to repair, they can only maintain for a short time. Around the year, the surface damage is more serious.

Fig1. Barrage damage map

2.2 The pebble laying method affects its stability

Since the surface of the pebbles is very smooth, the binding force of the concrete to the pebbles depends on the way the pebbles are laid. There are two ways to inlay the pebbles into the concrete surface, horizontal laid and vertical laid (Horizontal laying: big side up, vertical laying: small side up). Due to the large water flow of the Shangmaji weir, in this situation, the surface of the weir should be pavement and concrete, and the proportion of cement should be large, so that the pebbles insert the cement deeper and ensure that the combination is stronger. The pebbles are not washed away by the flood[6].

The overflow platform of the Shangmaji Barrage adopts the laying method of "leveling one layer, standing three layers, and leveling one layer"[7], so that the laying method will make the pebble on the outermost edge easily washed away by the large flow, and the inner side Laying pebbles is relatively safe. When a large flow of river water passes through the top platform of the embankment, the arc will fall on the middle or the outermost side of the lower platform, so the laying method of the inner pebbles is not restricted. As shown in Figure 2, the pebbles of the barrage basically fall off the outermost part first, causing the damage gap to become larger and larger, extending to the inside of the platform, exposing the concrete cushion.

Fig2. Shedding of outermost pebble

2.3 The pebble concrete layer and the cast-in-situ concrete have low adhesion

From the site damage, it can be seen that the pebble concrete layer and the surface cast-in-situ concrete with a thickness of 1m are a staged construction process. After the surface cast-in-situ concrete layer is completed, the curing and solidification of the surface layer are completed, and then the pebble concrete layer is laid for the second time. The process will cause the pebble layer and the cast-in-place layer to be unable to form a whole, and the bonding force is not strong enough. When a pebble is washed away, the surrounding pebble layer will suffer joint damage.

After the maintenance operations in recent years, partial repairs were also carried out, and the pebble layer and the lower cast-in-place concrete layer could not be formed as a whole, and the maintenance effect was not obvious.

2.4 The impact of concrete shrinkage

Concrete shrinkage is divided into three situations: drying shrinkage, spontaneous shrinkage and carbonization shrinkage. Among them, the drying shrinkage has the greatest impact, and is affected by the external environment, and the adsorbed water inside will evaporate over time[8]. Concrete shrinkage is directly related to internal factors such as water-cement ratio, cement dosage, aggregate, etc. External factors such as age, loading stress, and duration also directly affect concrete shrinkage.

The surface of the Shangmaji weir is inlaid with pebbles, and the shrinkage of the pebbles is negligible. The dam is directly exposed to the outside for a long time each year. In high temperature weather, the concrete thickness of the pebble concrete on the surface is about 5 cm, which is relatively thin. The drying shrinkage will reduce the bonding force between the concrete and the

pebbles. When the overflow area of the weir is large, the scouring force of the pebbles on the surface of the weir will be greater, causing local damage.

3 3 Reinforcement and repair measures

3.1 Drilling, grouting and vertical paving cobble reinforcement method

3.1.1 Construction preparation

Construction tools include hand air drill, mixer, grout pump, grout pipe[9]. Before construction, clarify the spacing of the holes, the number of holes and the position of each hole. The width of receiving water step is 1.6m and the length of the weir is 180m. Therefore, two rows of vertical holes are used. The outer row is 0.45m from the outer edge, and the inner row is The distance between the holes is 0.45m from the inner edge, the distance between the two holes is 0.61m, the number of holes in each row is 90, the spacing is 2m, and there are 180 holes in total[10]. The borehole diameter is 45mm and the depth is 1.1m. Before construction, the pebble concrete within the radius of 0.2m with the center of the hole as the center is knocked out. When grouting, the concrete is poured in this area together, and then the pebble is erected to Make the pebble concrete and the lower layer become a whole, strengthen the bonding force between the pebble concrete and the concrete layer, and strengthen the stability of the weir.

3.1.2 Construction process

The drilling and grouting vertical paving pebble reinforcement method uses a 40mm PVC pipe inserted into the grouting hole, and the penetration depth is not less than 30cm[11]. When grouting, seal the contact point between the PVC pipe and the borehole, and keep the grouting pressure between 0.2 and 0.5Mpa. When grouting, the principle of first outside and then inside is used[12]. Now the outermost hole is grouted, and then the inner hole is filled. After the grouting overflows, pour a circular area with a surface diameter of 0.4m to a thickness of 6cm, and then pave the pebbles tightly into the concrete so that the upper surface of the pebbles exposes the concrete, and the exposed height shall not exceed 1cm.

3.1.3 Benefit Analysis

It can be seen from other similar domestic cases that this reinforcement measure is convenient to construct, has a short period, and has obvious effects. The pebble concrete on the surface and the concrete layer are tightly bonded and reliable, so that it can play its role even in the large flow of water, without damage.

3.2 Method of increasing the width of receiving water step

The height of receiving water step of the Shangmaji weir is 0.46m and the width of receiving water step is 1.6m. Therefore, the area is a flood-prone area. Combined with the damage of the weir, it can be seen that when the height of receiving water step remains the same, the width of receiving water step needs to be lengthened to relieve the scouring force of water on the step.

3.2.1 Construction preparation

Understand the structure of the dam before construction, and redesign the receiving water step of the dam. Since the pebble concrete and the concrete layer are not well bonded, the width of receiving water step needs to be lengthened to alleviate the shear damage caused by the impact of the water flow on the pebble layer. The width of the designed receiving water step is 2.2m, and the length of each receiving water step must be widened.

3.2.2 Construction process

The method of increasing the width of the receiving water step is to knock off the pebbles on the top surface of each layer on the weir. Construction according to the height of receiving water step is 0.6m and the width of receiving water step is2.2m, a total of five layers of platforms are used to Pouring concrete. After the maintenance is completed. Apply 6cm thick concrete on the surface, re-use the knocked-out pebbles and lay them on the concrete layer, so that the concrete fully wraps the pebbles, and the exposed pebbles at the top do not exceed 1cm. The side pebbles are laid with the same process, and concrete is used between each layer of pebbles. Pack tightly so that it fully envelops the pebbles.

According to the construction of the weir dam according to this operation, the concrete bottom plate downstream of the weir will not reach 7m in length, so the bottom plate needs to be lengthened. Excavate the outer edge of the bottom plate until the total length of the bottom plate is 7m, and the thickness is controlled to 1m thick. The support formwork is poured with concrete. After solidification, the formwork is removed and maintained to the design strength.

3.2.3 Benefit Analysis

It can be seen from similar domestic cases that extend the the width of the receiving water step has a significant buffering effect on water flow. Many engineering cases failed to buffer the impact of water flow, resulting in damage to engineering buildings. Increasing the length of the drop platform has the same effect as reducing the height of the drop platform, but the former is simple to construct, has a short cycle, saves a lot of human resources, and brings considerable economic benefits.

4 Conclusion

The damage of Shangmaji barrage is very common in our country, but the solutions are only partial repairs, which can’t solve the actual problem. This thesis gives two solutions for this. The drilling, grouting, vertical paving fundamentally solves the pebble the problem of shedding

is applicable to a variety of infrastructure construction cases. It not only preserves the ecological pebble layer on the surface, but also strengthens the overall structural stability of the weir and increases the service life of the weir; extend the width of receiving water step can effectively alleviate the flow of water the impact force not only meets the mechanical performance requirements, but also fundamentally solves the problem of pebble shedding.

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