

# Study on the Leakage Damage Mechanism and Repair Technology of Shangmaji Weir

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**Abstract:** As a type of dam with a long history and a wide range in the construction of water conservancy projects in my country, weir dams have the functions of flood control, irrigation and diversion. Due to the limitation of construction conditions and environment at that time, the treatment of weir and dam is not standardized enough, which leads to different degrees of problems in weir dam. Based on the example of Shangmaji weir, the article focuses on the analysis of the leakage damage mechanism of the weir, and proposes to choose the corresponding technology to repair it from two angles of the water-facing slope.

## 1 Introduction

As an important water conservancy project facility, the weirs in Zhejiang area can not only solve the problems of drinking water for humans and animals and irrigation of farmland, but also have the function of blocking sea water and gather fresh water and eliminating flooding. According to investigation, there are thousands of large and small weirs in Zhejiang. However, in the actual construction process, the quality of the weirs cannot be guaranteed due to the influence of on-site construction environment and construction technology, and various problems are prone to occur. Such as leakage, cracking, damage, etc, which seriously threaten the life and property safety of the people<sup>[1]</sup>. For the anti-seepage treatment of the weir, many scholars at home and abroad have proposed many methods to deal with it: There is an option to use circular grouting, that is, insert two pipes in the borehole, and the slurry that is pressed into the borehole will fill the gap, and the other part will return to the mixing drum and other boreholes from the gap, which makes the slurry always flow State, no precipitation, so the grouting effect is good<sup>[2]</sup>; The filling grouting method is mainly used to inject the grout into the hidden troubles of the dam body by using the grout's own weight<sup>[3]</sup>; The relatively complete high-pressure jet grouting technology can easily form an impermeable wall in the soil to achieve the ultimate goal of imperviousness. This type of technology is mainly suitable for silty sand with large sand content and gravel with a particle size of less than 15cm Fine sand<sup>[1]</sup>; The anti-seepage technology for backfilling the impervious wall and the clay inclined wall of the punching sleeve well mainly uses punching-type well drilling tools to make holes in the impermeable body of the earth-rock dam, and then use the cohesive soil for layered backfilling to form a continuous clay anti-seepage wall

and the soil layer of the shaft wall are compressed to make the soil around the wellhead compact, so as to achieve the purpose of anti-seepage and reinforcement<sup>[4]</sup>; The “top-down and bottom-up integrated grouting method” used in the dam of the South Russia 3 Hydropower Station in Laos can not only build curtain walls that meet the design requirements, but also grouting method reduces the risk of the plinth being lifted and also reduces the project cost<sup>[5]</sup>, compare to the traditional “orifice closure”.

At present, the grouting technology and research in the dam body has gradually been perfected and matured, and more scholars are conducting research in this filed, but these are all for the repair and reinforcement of large dams, and for small stone masonry, the research on repairing technology of dams and weirs is particularly lacking. The application of grouting technology to small weir dams, on the one hand, is due to the limited construction site of the dam, and the transportation of materials and equipment is not convenient enough, which is not conducive to construction and has a long construction period, another aspect is to consider economic applicability. The case studied in this paper -- Shangmaji weir, the elevation of which is 130.7m, the main material of the dam body is filled with C20 concrete and masonry, and the surface layer is cast-in-place concrete of 1m thick C25; The dam adopts an open, broken-line practical weir design, with five levels of water drop, the drop height is 0.64m, the drop platform is 1.6m, and the top of the weir is cobbled; the cross-sectional length of the dam body is 9.4m, and 7m long and 1m thick C25 concrete bottom protection is installed downstream of the dam. In response to the above problems, based on the results of field investigations, carefully analyze their causes, and design a reinforcement plan suitable for the weir based on the desired treatment effect to extend its service life.

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## 2 Analysis of leakage failure mechanism

### 2.1 Influence of seepage diameter

Shangmaji Weir is located in Wanyao Irrigation District. The irrigation area is located in valley basins and hilly areas on both sides of the middle and lower reaches of Jiangshan Port. It has a low geographical latitude and belongs to a subtropical monsoon climate zone. The main climate characteristics are warm and humid, four distinct seasons, and abundant rainfall. The main disasters are low temperature, cold current, rainy season and typhoon<sup>[6]</sup>. Therefore, the water flow of the weir is the largest in April to June, and the cross-section of the entire weir is only 9.4m. The designed seepage diameter is too short to meet the requirements of the seepage diameter length in the high water period, which results in the weir a certain degree of leakage occurs. (Figure 2)



Fig 2. Cross-sectional view

### 2.2 Foundation deformation

The Shangmaji Barrage is located in the lower part of the Nanxiong Formation of the Upper Cretaceous. The lithology is mainly brick red and blue-gray siltstone, argillaceous siltstone, glutenite, etc<sup>[7]</sup>. This kind of rock belongs to geological soft rock with low strength. For example, siltstone will degenerate into schist or gneiss under high temperature and high pressure environment, which will cause the internal stress of the dam body to change due to different pressures, which causes due to the difference in load, the foundation will gradually deform, and the small cracks will gradually expand to large cracks, so the phenomenon of leakage will also occur, and the porosity of this type of rock is large, and the degree of cementation is low, which will also affect the weir to a certain extent. The overall anti-seepage function leads to the destruction of the weir.

### 2.3 Lack of anti-seepage treatment at intake

There is a water intake on the left side of the weir. The

survey data shows that the water intake is 1.8m wide and 1.4m deep. It is only lined with concrete and has no anti-seepage measures (Figure 1). Therefore, when the water flows through the water intake, it is easy to seep to both sides. Under the long-term water infiltration, the weir will also leak and damage.



Fig 1. Leakage at the intake

### 2.4 Construction impact

During the construction of the weir, there may also be many problems leading to leakage. For example, the grouting stones are not dense enough during the construction process to make them staggered; the water stop on the water surface of the weir is broken or damaged; the concrete is not mixed uniformly during the transportation process, causing the poured concrete to produce pitted surfaces and air bubbles; Vibration is not dense enough to cause cracks and collapse in the concrete between the grouting stones. These construction influences will eventually lead to the emergence of cracks. If the cracks run through the upstream and downstream, water leakage and seepage will be caused, and eventually the whole weir will be gradually damaged, unable to play its due function, endangering the safety of people's life and property.

## 3 Reinforcement and repair technology research

In the prevention and reinforcement of weirs and dams, in view of the problems that arise, we must first conduct a serious investigation of damage and start from the root cause; rely on the results of field investigations to analyze the causes and take targeted measures to ensure that the weirs reliable construction for removing danger and strengthening.

### 3.1 Principles of leakage treatment

(1) According to the leakage investigation, cause analysis and the expected effect achieved through the

requirements of leakage treatment, evaluate the shape, specification and direction of the crack, and select a reasonable reinforcement plan based on the structural characteristics of the weir, the actual situation, and the climate and environmental conditions, repair materials and construction time.

(2) The leakage treatment should be as close as possible to the source of the leakage. If conditions permit, anti-seepage treatment can be carried out on the front surface.

(3) Leakage treatment should first be constructed during the dry season of the river, first stop the leakage and drain, and then install the waterproof layer.

(4) When selecting repair materials, compare and analyze five aspects: treatment effect, durability, ease of construction, pollution-free, and economy<sup>[8]</sup>.

### 3.2 Leakage treatment method

(1) For the treatment of cracks on the waterfront surface, on the one hand, surface covering materials can be applied. This method is the simplest and easy to operate method in adding an impermeable layer on the waterfront surface, which can greatly shorten the construction period and is economical commonly used surface covering materials include asphalt mortar, rubber sheet and acrylic emulsion mortar<sup>[9]</sup>. In the construction, firstly, the original dam surface must be humped, washed, etc; and the polymer mortar application process must be carefully mastered to achieve a good leakage treatment effect; on the other hand, you can choose to use sprayed concrete panels. This method does not need to erect a template, the construction is relatively simple, and the construction period is short.

(2) For the anti-seepage treatment of the water intake, because it is necessary to ensure the amount of water diversion, it is not suitable for large-scale thickening repair, so a relatively simple anti-seepage plan can be adopted, that is, laying geomembrane. Geomembrane is a coiled material, which is convenient for transportation, convenient for construction, and short construction period. At the same time, the cost of using in an anti-seepage system is 30% or more lower than that of a traditional reinforced concrete anti-seepage structure. And the geomembrane has strong acid and alkali resistance, anti-aging, anti-ultraviolet abilities, and can be used quickly in various complex environments and is durable. Geomembrane can be used together with non-woven fabrics. Non-woven fabrics have a rough surface and can generate greater friction with the contact surface to ensure that the geomembrane and the protective layer are in a good and stable state.

(3) For cracks and leakage in the dam body, drilling and grouting can be used. In the past, high-pressure jet grouting or filling grouting was generally used, but because the width of the cracks changes with temperature and load conditions, cement mortar and grout are rigid materials, and it is difficult to adapt to the changes in the width of the cracks with changes in the external environment. So the repair effect is not good.

Therefore, it is now beginning to promote the application of chemical materials for grouting, and have achieved better results. The materials that can be selected are lignin grouting materials, water glass grouting materials, epoxy grouting materials, acrylamide grouting materials, etc<sup>[10]</sup>.

(4) During the implementation of the reinforcement construction, the mixing and pouring of the concrete should be strictly inspected to avoid the occurrence of pitted surfaces and air bubbles due to insufficient mixing, which may cause secondary damage to the weir.

### 3.3 Benefit Analysis

Because there are few domestic research literatures on the analysis of small-scale dams and their related reinforcement, and there is no unified design specification and technical standard to provide reference for the prevention and remediation of dams, this article is a comprehensive study of large-scale dams. Infiltration analysis and other relevant water conservancy facilities research experience to discuss and analyze. Through the scheme discussed in this article, the leakage problem of the weir can be effectively solved, and the construction is simple, fast, and the treatment effect is good, and it has sufficient durability, safety and economy.

## 4 Conclusion

As a small stone masonry dam in Zhejiang area, Shangmaji Barrage is representative of its leakage damage. Combining the scheme given in this article, the anti-seepage treatment from the water-incoming surface and the water-intake can effectively solve the local leakage and dispersion problems of the dam body, and the construction is convenient and easy to operate; chemical grouting from the inside of the dam body, it can greatly avoid the problems caused by load changes and deformation, and enhance the anti-seepage ability of the weir.

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