Grouting Construction Technology in Anti-seepage Treatment of Reservoir

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Abstract. At the current stage, with the rapid development of society, it has also driven the rapid development of reservoir dams. Many reservoir dams now need to use multiple anti-seepage technologies to strengthen and remove dangers. Different methods have different advantages, which are more applicable to different dam functions or geological conditions. When carrying out the danger-reinforcement and reinforcement, the best anti-seepage treatment technology is selected through different situations, so as to achieve the best quality of the reservoir danger-reinforcement and reinforcement project. In view of this, this article has carried out a detailed discussion on the grouting and anti-seepage treatment technology in the reservoir's danger-reinforcing and reinforcement construction, in order to provide a more intuitive reference for the industry and make contributions to the development of reservoir dams in the future.

1. Introduction
At present, with the rapid development of society and economy, the rapid development of water conservancy projects has also been promoted. As an important foundation project for people's livelihood, water conservancy projects are directly related to social stability and economic development. After the construction of the reservoir project is completed, one or more problems may occur. To ensure the stability of the dam to the greatest extent, regular inspection of the reservoir must be done, so that the reservoir can be handled in time. Hidden dangers, so as to effectively ensure the safety of the dam and better benefit the people.

At present, the main anti-seepage technologies can be divided into the following four as shown in Figure 1: (1). Split curtain grouting and anti-seepage technology was invented by Chinese technicians. It was widely publicized and became a key science and technology project. In some special geological conditions, split curtain grouting technology can be used, such as anti-seepage treatment of earth embankments and dams on low foundations. This technology can improve the seepage stability of the dam foundation under the vertical continuous anti-seepage curtain, and can prevent the deformation of the dam body to the greatest extent. (2). High-pressure jet grouting and anti-seepage technology is an anti-seepage treatment technology introduced from Japan. It is more suitable for foundation reinforcement projects. Through a series of transformations, it can also be used well in the early stage. Anti-seepage treatment of ground contact belt and cover layer. (3). As a new type of anti-seepage construction technology, geomembrane anti-seepage technology mainly uses the new geomembrane material to reinforce the reservoir. This technology is not only suitable for the anti-seepage treatment of new reservoirs. And it can also be used in the construction of anti-seepage reinforcement works of built reservoirs. (4). During the "Ninth Five-Year Plan" period, the technology of the vibrating-sink impervious plate wall was promoted as a key scientific and technological project, and has been widely
used. Generally, this technology is used in the protection of dykes and dykes. Good effect in infiltration treatment. The key method of this technology is to strengthen the anti-seepage through the use of ultra-thin concrete walls. In addition to the commonly used reservoir reinforcement and impervious technology mentioned above, there is also a grouting impervious technology for graded ingredients, which is more suitable for the geology of Castel. It has become the most widely used anti-seepage technology at home and abroad; according to the geological conditions of the dam body and different causes, it is necessary to comprehensively select the best and most suitable comprehensive treatment technology for anti-seepage measures, so as to achieve better dam impervious treatment.

2. Anti-seepage treatment technology

By carefully understanding the specific details of this project, and comparing the advantages and disadvantages of various anti-seepage treatment technologies, the actual geological conditions of the reservoir were analyzed and considered. Finally, split grouting was used for the reinforcement and danger removal of the reservoir. Reinforcement technology, the effect of applying this anti-seepage treatment technology should be the best, its main economic advantages, good grouting quality, and fast construction speed are the main advantages, especially for those downstream leakage, dam body cracks and poor quality the disease reservoir is more suitable. This project combines the stress distribution of the dam body and the thunderbolt law of the dam foundation. The layout of the boreholes is mainly carried out along the axis of the dam body. Based on previous construction experience, it is inferred that the spacing of the dam foundation split holes should be 2-3 meters. The combined design requires that the grouting hole spacing of the project is 2 meters, and two rows of drill holes are set at the top of the dam. The distance between the rows is 1m and the hole spacing is 2m. After the split grouting technology of this project is combined with the relevant technical specifications and standards, grouting requires the use of hole bottom grouting and full-hole infusion. According to past experience, it is well known that the use of mud rotary rotation drilling to make holes will use different degrees of split dams. As soon as the irrigated mud does not meet the requirements of the actual standard, it will cause the dam body grouting and anti-seepage treatment technology to lose its effect. Therefore, it is best to apply dry boring. Therefore, in the project, 10% to 15% of cement is mixed into the poured clay mixed slurry. Therefore, the slurry of this configuration has good stability and fluidity, as shown in Figure 2. Based on the consideration of the standard grouting thickness, this method is used to After the slurry is configured,
the self-coagulation effect of the slurry will reach the optimal state after 4-5 days, so that the final formed stone has strong impermeability, and at the same time, the final specific design standards and strength standards are achieved.

![Diagram of Drilling Machine](image)

**Figure 2.** The Drilling machine used for the stability and fluidity of water seepage protection

To the actual required standard. 3. Quality control points of grouting and anti-seepage technology The main quality control points of grouting technology applied to this project are as follows: ① The design of grouting holes must be arranged in double rows along the embankment axis and ensure that the drilling is vertical; ② During the grouting work, it needs to be carried out in stages, in sequence, and in sections, and the bottom hole must be grouted first to ensure that the grouting tube and the bottom of the grout plane maintain a distance of about 0.5m; ③ pay attention to the configuration Develop from thin to thick, and ensure the density of 1.2 to 1.5g/cm³ and the grouting pressure of 130 to 380 kPa, to ensure that each hole grouting exceeds 5 times, each grouting time exceeds 5 days; ④ Use thick slurry as the final until the slurry does not sink. In the grouting anti-seepage treatment technology for the construction of the reservoir, the drilling holes are arranged along the axis, and the high-pressure is used to fill the dam foundation with mud, and finally the grout Impervious curtains are formed and proceed from the middle to the sides and from the bottom to the top. Therefore, the dam is unevenly filled and is easily affected by stress. Through analysis and observation of the cracks on the top of the dam, it can be clearly determined whether the grouting technology used in this project can meet the requirements of the reservoir dam. In the design, the project has a grouting thickness of 5 cm. The required soil volume can be calculated through the calculation formula of the thickness of the slurry curtain. The final value should be 0.8 m³. After the actual calculation and analysis of the specific filling amount, we can know that the actual filling amount is higher than the calculated value. Therefore, it is judged that the grouting effect of the project fully meets the actual needs.

3. Analysis of construction points

3.1. Process flow for the test
The main purpose of the test section is to verify that the technical parameters of the grouting
construction proposed in the design are feasible in the actual dam site area and whether the grouting effect can reach the expected index, and determine the relevant grouting parameters that will ultimately guide the construction. Therefore, the selection of the test section is very critical. According to the geological conditions of the dam foundation provided by the construction drawings, the curtain grouting test is divided into four areas. After the test, the originally designed fourth-sequence hole was changed to the third-sequence hole construction process, combining the actual site. In some cases, different grouting methods are adopted in different areas, and the block-type bottom-up segmented grouting method and the top-down segmented grouting method are mainly used. The main process of the construction process is to first perform drilling and hole-forming operations, and then perform grouting operations after flushing and pressure water testing, and finally perform hole sealing.

3.2. Application analysis

During curtain grouting construction, grouting holes should be arranged at the design position of the anti-seepage axis. Pilot holes should be arranged in the first grouting of the curtain grouting or in the main curtain holes. The pilot holes should be selected in a sequence of holes with a spacing of 16 ~ 24m, usually one- or two-unit projects can be arranged, and the pilot holes of double-row and multi-row holes should be arranged first in the deepest row of holes, as shown in Table 1. According to the actual conditions of the site, the Zhuangli Reservoir project has a pilot hole every 24.0 m for single-row curtain grouting areas, and a pilot hole every 16.0m for double-row and triple-row curtain grouting.

| Hole depth (m) | 40  | 50  | 60  | 70  |
|----------------|-----|-----|-----|-----|
| Maximum allowable deviation (m) | 0.5 | 1.2 | 2.3 | 3.4 |
| Minimum allowable deviation (m)  | 0.3 | 0.5 | 1.1 | 1.4 |

When drilling, the construction order should be strictly followed. The drilling of the downstream row will be performed first, followed by the upstream row, and finally the construction of the middle row. At the same time, when the drilling of the upstream and downstream rows is performed, the spacing of the pilot holes should be Controlled around 16m. In addition, the grouting section length should be reasonably divided, and the section length can be determined as 2, 3 and 5 m in order from top to bottom, and the remaining section lengths should be about 5m to 7m; if the construction site When the geological conditions are good, the grouting section length can be appropriately lengthened, but it should still be controlled within 10m. Drilling and flushing refers to the use of clear water or compressed air and water to flush out the debris at the bottom of the hole, and other debris such as rock powder from the hole wall, to achieve the purpose of facilitating slurry injection. Strictly speaking, punching is drilling as part of the hole process, the hole should be punched in time after the drilling is completed, and the hole should be protected to prevent sewage from flowing in or foreign matter falling into it. The characteristics of punching are that the orifice is not closed and the amount of water in the flushing water is large, but the pressure is not necessarily large. The flushing time is subject to the return water becoming clear, as shown in Table 2.

| Samples         | Reservoir A | Reservoir B | Reservoir C | Reservoir D |
|-----------------|-------------|-------------|-------------|-------------|
| Flushing time   | 24          | 36          | 48          | 60          |
| Clear degree    | 30          | 50          | 63          | 76          |

The punching requirement is that the thickness of the bottom of the hole after flushing is not greater than 20cm. Fissure flushing is to use pressure water to flush out the soft weathered mud filled in rock cracks or voids. The flushing pressure can be 80% of the grouting pressure, not more than 1.0MPa, and the flushing time until the return water is clarified or not more than 20min; when the bottom-up stage grouting method is used, the grouting hole can be performed once before the grouting.
test refers to a test in which fresh water is pressed into a drilling test section, and the relative water permeability of the rock mass and the degree of crack development are calculated based on the relationship between the amount of water pressed in and the applied pressure within a certain period of time. The pressure test of pilot hole and inspection hole generally adopts the single-point method, and the top-down segmented cyclic grouting method or the orifice closed grouting method is used for curtain grouting. The ordinary grouting hole generally uses simple pressurized water, and the flow state is required. The analysis inspection hole and the grouting pilot hole and inspection hole with precise requirements need to use three-stage pressure and five-stage five-point method to pressurize the water. When using the bottom-up stage grouting method, simple full-hole water pressing can be performed before grouting. The pilot hole and the inspection hole shall be controlled at a pressure of about 80% of the grouting pressure when performing a pressure water test. Because the dam height of Reservoir is less than 50 m, when the grouting pressure exceeds 1.0 MPa, 1.0 MPa should be determined as the pressure water test pressure value.

4. Conclusion
Leakage problem is one of the common problems in the foundation construction of reservoir dams of hydraulic engineering. Through the application of curtain grouting technology, the foundation structure of reservoir dams can be effectively treated to prevent seepage and to extend the service life of hydraulic engineering. The construction unit should fully grasp the application points of curtain grouting construction technology, scientifically select the construction process method, reasonably allocate the construction equipment personnel, and at the same time, strengthen the technical training of the construction personnel to ensure that their technical level can meet the requirements of curtain grouting construction and improve the curtain quality and efficiency of grouting construction.

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