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Discussion on Anti-Seepage Technologies in the Construction of Small-Scale Rural Water Conservancy Projects

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Abstract: In order to ensure the sustainable growth of rural economy, it is necessary to carry out further research on small-scale water conservancy projects and solve the seepage issue in rural areas. Based on the application significance of small-scale rural water conservancy projects and the analysis of anti-seepage technologies, along with specific examples, this paper specifically discusses the application of high-pressure jet technology, so as to provide reference for the development of engineering construction.

Keywords: Small-scale water conservancy projects; Rural areas; Anti-seepage technology; High-pressure jet

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1. Introduction

The development level of water conservancy construction largely determines the national economic development level, especially the development of the agricultural industry. The construction quality of water conservancy projects has a significant impact on the grain output and agricultural income. However, from the analysis of the current situation of small-scale rural water conservancy projects in China in recent years, seepage problems often occur, bringing huge loss to rural areas. In addition, due to the limitation of agricultural conditions, the difficulty in anti-seepage construction is doubled. Therefore, it is crucial to carry out further research on anti-seepage technologies and ensure the steady improvement of the construction quality of water conservancy projects through the scientific application of relevant technologies. Upon analyzing the quality issues of small-scale rural water conservancy projects in China, several scholars have found that the main reasons for seepage in these projects are insufficient investment funds, poor geological conditions, harsh environment, and insufficient or late maintenance [1]. In order to solve these problems efficiently, the causes of the problems should be deeply considered prior to adopting anti-seepage technologies, so as to realize the stable improvement of the quality of these water conservancy projects and ensure an increase in agricultural production as well as the safety of people's life and property.

2. Significance of strengthening the research and application of anti-seepage technologies in small-scale rural water conservancy projects

Small-scale water conservancy projects in rural areas function for flood and disaster prevention, agricultural irrigation, and as a guarantee for water supply. Therefore, the construction of small-scale rural water conservancy projects has been increasing in various regions around the country. Through the application of relevant anti-seepage technologies, the quality of these projects has been improving; the stability of water storage and water transmission is now guaranteed; the level of agricultural irrigation and the quality of water supply to the people have shown improvement [2]. In the construction of small-scale rural water conservancy projects, scientific design must be carried out in line with the geological structure and topographic conditions of the site as well as supplemented by the application of scientific and effective anti-seepage technologies, so as to ensure that the project structure remains functional, and thus ensure the safety and stability of the operation.

3. Key anti-seepage technologies in the construction of small-scale rural water conservancy projects

With the gradual increase of water conservancy projects, the requirements for quality engineering construction are higher. Under this background, various anti-seepage technologies have emerged one after another. Several key anti-seepage technologies are briefly introduced in the following sections.

3.1. Split grouting technology

The split grouting technology of earthen dam body splits the dam body along its axis according to its stress distribution law. A certain amount of mud is poured to form a vertical anti-seepage wall, so as to ensure the quality of the dam body and improve its stability [3-5].

3.2. Chemical reinforcement treatment technology

Chemical reinforcement treatment technology is a common anti-seepage technology in the construction of small-scale rural water conservancy projects. In the application of this technology, the leakage from the dam body is repaired with high-performance epoxy mortar to stop the loss in time. However, in the application of this technology, it is important to pay attention to the cleaning of sundries on the concrete surface and to reduce the soil content in the concrete. After the epoxy mortar is filled, the wood board should be used for compaction to assure the technology’s application effect [6].

3.3. High pressure jet grouting technology

High pressure jet grouting technology involves the use of a high-pressure equipment to spray the slurry until it leaks out, so as to realize the rapid integration of cement slurry leakage and bottom soil irrigation as well as form a wall like consolidated body, thus achieving a better leakage treatment effect [7].
The process flow of high-pressure jet grouting is shown in **Figure 1**.

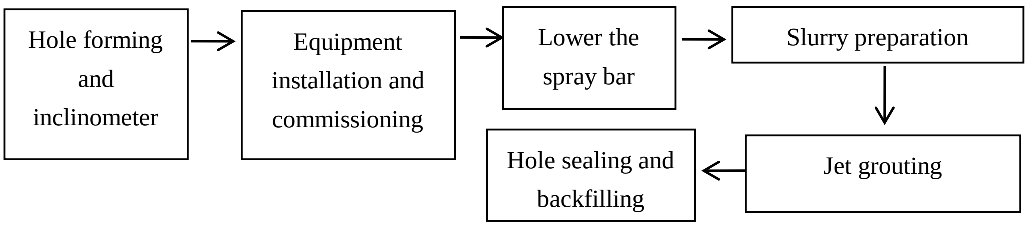

Figure 1. Process flow of high-pressure jet grouting technology

3.4. Controlled grouting technology

Controlled grouting technology is a new anti-seepage technology in water conservancy and hydropower projects. Based on the optimization and adjustment of traditional grouting technology, this technology realizes the reasonable control of slurry pressure and flow, ensures the effective control of grouting scope and quality, as well as greatly saves the construction progress and cost of hydraulic engineering.

3.5. Asphalt concrete anti-seepage technology

Asphalt concrete technology is mainly used in water conservancy projects that are carried out in cold areas, especially in North China. Its main advantage lies in the high durability and stability of asphalt concrete materials [8,9]. In the application of this technology, asphalt material is first heated at a high temperature and then injected into the dam body and channels that leak easily, so as to lay a solid foundation for the high-quality construction of small-scale water conservancy projects in countryside as well as improve the service life and performance of water conservancy projects.

3.6. Membrane material anti-seepage technology

The application of membrane material anti-seepage technology mainly involves adding protective layers onto civil engineering molds or plastic films in the construction of water conservancy projects, so as to ensure the rationality of irrigation and reduce the risk of seepage [10-12].

4. Application of high-pressure jet grouting technology in the construction of small-scale rural water conservancy projects

The geological site conditions of a small-scale rural water conservancy project are as follows: the soil layer 41.5 m above the dam body has miscellaneous fill, silty paste, medium fine and coarse sand layers, as well as silty clay layer; the depth of the grayish yellow medium fine sand layer ranges from 41.5 to 44.8 m, with a small amount of gravel with a diameter of 11~29 mm locally; the survey area 44.8 m below is clay, containing a small amount of ginger like calcium core, and the stable groundwater level is -3.9 m. From the geological survey, the geological conditions of the site are complex, and the issues that require attention in the construction are quicksand control and seepage control.

4.1. Process parameters and equipment selection

The process parameters and curtain effect of the high-pressure jet waterstop curtain are limited by the performance of the sprinkler irrigation machinery [13,14]. Therefore, in order to ensure the construction quality, the design parameters of the project are as follows: water pressure is 36-40 MPa; flow is 70 L/min; slurry pressure is 0.5 MPa; air pressure is 0.6~0.8 MPa; air flow is 1 m^3/min; lifting speed is 10~15 cm/min; the rotary speed and swing speed of the rotary jet are designed to be 0.8 times of the lifting speed (**Table 1**). The equipment mainly includes 3 drilling rigs (DP-100 Rotary Drilling Rig); 3 sets of drilling equipment (50 mm); 2 high-pressure jet trucks (CYP-90); 2 high-pressure mud pumps (50 MPa); 2 air compressors (60 m^3); 3 mud pumps (80); 3 mixers (JS500).

4.2. Layout of the grouting hole

Based on the requirements of building collapse and anti-seepage, 69 holes are formed in the sand section of the dam body (hole spacing: 2 m; hole depth: 48.9 m), and the grouting treatment range is 37.8~46.9 m.

4.3. Forming a hole

Based on the design requirements of the project, the second sequence hole is selected for construction; the spacing of the first sequence hole is 2.0 m, and the DP-100 Rotary Drilling Rig is used for drilling. The pilot hole is first constructed, and the construction is then carried out according to the principle of two sequence and gradual densification of high-pressure rotary jet grouting holes. The hole depth exceeds the design depth by 0.4 m.

Table 1. Process parameters of high-pressure jet grouting technology

Serial number	Project		Unit	Process parameters
1	Water	Pressure	MPa	36-40
		Flow	L/min	70
2	Slurry	Pressure	MPa	0.5
		Flow	L/min	0.6-0.8
3	Gas	Pressure	MPa	0.7
		Flow	L/min	1
4	Feed density		g/m³	1.62
5	Return density		g/m³	1.39
6	Lifting speed		cm/min	10
7	Rotary speed		r/min	8
8	Swing speed		r/min	8

4.4. Slurry preparation

(1) Cement: Pure Portland cement slurry is used, in which the cement strength is 32.5 R; the slurry is sieved before use.

(2) Water: Use the construction water for concrete mixing.

(3) Admixture: According to the material ratio test, an appropriate amount of bentonite is added to the slurry preparation after the slurry performance is changed and approved by the supervision engineer.

The slurry is prepared uniformly according to the test proportioning requirements, configured by the weight method, and the error is strictly controlled within 5%. The water cement ratio is controlled at 1:1~1.5:1; the slurry density is strictly controlled within 1.65 g/cm³, and the slurry return density is controlled within 1.41 g/cm³.

When the external temperature is lower than 10°C, the slurry after preparation is used up within 5 hours; when the temperature exceeds 10°C, it does not exceed 3 hours. If the slurry is stored for a long time, it is treated as scrapped material [15-17].

4.5. Jet grouting

After the hole is formed, the equipment is moved to the vicinity of the hole mouth after the drilling has been completed. After the debugging, the nozzle of the spray rod is switched on and the orifice with iron cover is covered. Then the high-pressure water pump, air compressor, pulping machine, and mud pump are turned on to direct water, gas, and slurry. Any blockage or leakage in the joint or pipeline is checked [18].

After the completion of equipment debugging, it is necessary to use the winch to slowly lower the injection pipe to the bottom of the hole after the water pressure, air pressure, and equipment are running normally. It can spray statically for 2 to 3 minutes initially, and then increase when the specific gravity of the slurry coming out of the orifice reaches 1.25 g/cm³. If there is no slurry emission at the air port during sprinkler irrigation, the lifting is stopped immediately until the specific weight of slurry emission at the air port reaches 1.25 g/cm³. Subsequently, it is lifted slowly, and the machine is moved after lifting to the design height.

When the jet grouting construction is completed, the static pressure grouting is carried out immediately to continuously pour the caving back into the hole. In the process of reinjection, the filling is carried out at the same time as the sedimentation; the hole sealing and backfilling are carried out until there is no water precipitation, so as to avoid hole problems caused by water precipitation and shrinkage of slurry after the construction of high-pressure sprinkler irrigation, which will compromise the overall quality [19].

4.6. Grouting effect inspection

Following the formation of the waterstop curtain, through water injection test, the measured permeability coefficient of the curtain is less than the design allowable value, indicating that the quality and anti-seepage effect of the waterstop curtain meet the engineering quality standards. This demonstrates that high-pressure jet grouting technology is fully applicable to quicksand layer geological waterproof engineering projects, serving as a useful technical reference for the design and construction of similar engineering projects [20].

5. Conclusion

In a nutshell, small-scale rural water conservancy projects have played a critical role in guaranteeing agricultural irrigation, household water supply, as well as flood and disaster prevention. Therefore, it is of great practical significance to strengthen the quality control in the construction of small-scale rural water conservancy projects as well as emphasize on the research and application of anti-seepage technologies in order to ensure the safety of people's property and promote the national economic level. The high-pressure jet technology described in this paper is an anti-seepage technology commonly used in the construction of water conservancy projects at the present stage. Taking into consideration of the actual construction of specific projects, this paper discusses the application process and results of this technology in detail, verifies the effectiveness of this technology, and provides useful technical guidance for the implementation of similar projects.

Disclosure statement

The author declares no conflict of interest.

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