Section model test analysis of gate

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Abstract: It is a common hydraulic problem to study the characteristics of the discharge flow and the energy dissipation and scour prevention of the downstream of the hub. At present, many hydro junction projects under construction are located in canyon reach, and the layout of hydro junction is limited by terrain conditions. Therefore, it is necessary to study and analyze the general layout scheme and discharge capacity through experiments. The key technologies and objectives of this kind of section model are put forward, which can be used for reference and guidance in the development of similar cross-section model tests.

1. Introduction
Through data collection, theoretical research, cross-section model and summary research, the flood discharge capacity and reasonable flood discharge operation dispatching mode of sluice are studied. The technically feasible, economic and reasonable layout scheme is proposed.

2. Analysis of advantages and disadvantages
The common types of hydraulic gate are plane gate and radial gate. The vertical lift gate has the unique advantages of simple structure, gate fabrication, installation, management, construction and maintenance. It is used as the main water retaining and discharging structure in many water conservancy projects. Radial steel gate is one of the most widely used gate types in sluice construction. It has the advantages of small lifting force, fast running speed, flexible operation, safe operation and beautiful appearance. It is the most economical gate type among many gates and has been widely used in the 1950s and 1960s.

2.1. Unfavorable factors
There are some unfavorable factors in the plane gate: ①There is gate vibration problem in the operation of plane gate, especially when it is flood control and discharge control, there is a large opening and partial opening, and the gate vibration is more prominent; ②The dam crest needs to set with a higher hoisting platform, which is not convenient for the maintenance and management of the hoist; ③The poor flow conditions caused by the gate slot during flood discharge are easy to cause the pier concrete Cavitation problem. The radial gate can avoid the above adverse factors of the plane gate. The radial gate is suitable for large orifice overflow, which is conducive to the flexible operation of the gate [1]: The radial gate and the plane gate are respectively opened and closed by hydraulic hoist and fixed winch. In practice, the hydraulic hoist is more flexible and easier to operate than the fixed hoist. The main disadvantage of the radial gate is that the support hinge of the radial gate is relatively low, which is easily to be impacted by the water flow and floating objects.
2.2. Scope of application
The selection of flood discharge is generally based on the topographical, geological and hydrological characteristics of the dam site and the inundation control of the reservoir area. For large discharge orifice of low weir, plane gate and radial gate are often used to block and discharge water. The gate type has great influence on the size of discharge structure, which can affect the layout of the whole complex structure. The downstream flow characteristics of different types of gates are not the same, so it is necessary to simulate various working conditions through experiments, comprehensively compare and select economic, reasonable and safe schemes.

3. Design and production
In the cross-section model test, it is necessary to study the discharge capacity in flood period and the rationality of energy dissipator. The geometric scale is more smaller, the error of model water depth, velocity and other parameters are more big, which cannot achieve the test purpose [2]. However, if the scale is too large, the test site cannot meet the requirements. Generally, according to the requirements of the test task, combined with the laboratory site, equipment and other conditions, the model is normal model, and the geometric scale is generally between 20 ~ 50.

3.1. Design and layout
In order to ensure the similarity of water flow in single width discharge, it need to eliminate the influence of the thickness of side wall laminar flow on the flow velocity and improve the accuracy of test results. The model test is carried out in a rectangular glass tank. Measuring instruments mainly include flow, velocity, pressure and water level. The inlet flow of the flume is controlled by the regulating valve and electromagnetic flow meter. Water level gauges are installed on the upstream, downstream and gate of the sluice gate. The water level is calibrated by measuring needle cylinder, which is used to observe the water surface profile of the sluice chamber and its upstream and downstream.

3.2. Objective of section test
Through the section model test and summary research, the flood discharge capacity and reasonable operation mode of flood discharge are studied. The comprehensive discharge coefficient and submergence coefficient of gate opening and downstream water level are determined, and the discharge relation curve of downstream single width under different combination of gate opening and downstream water level is proposed. The factors influencing the hydraulic characteristics and energy dissipation mechanism of energy dissipator are studied through test, which can effectively reduce the damage to energy dissipation facilities.

4. Discharge capacity test

4.1. Weir flow test
Taking one project as an example, the project is located in a mountainous canyon section with narrow river width. The test can solve the problem of flood discharge capacity and operation dispatching mode of the sluice gate and the layout of energy dissipator under the condition of narrow river channel, high mountains and deep valleys Setting scheme [3].

The sluice gate is one of the main water retaining and discharging structures in the project. Discharge capacity test sluice is one of the main water retaining and discharging structures of the project. In flood period, the discharge capacity of the project is to test and study the discharge capacity of the project according to the corresponding peak discharge of each frequency proposed[4]. Controlling the discharge and downstream water level of the model according to the water level discharge relationship are given by the design, and measure the water level and backwater level of the upstream reservoir area to judge Whether the discharge capacity of the fault junction meets the requirements. If it is less than the design value, it can be judged that the discharge capacity of the hub
meets the requirements.

4.2 Orifice flow test

This test will study the discharge capacity of the gate outlet at all levels of flow, and provide the basis for the operation and management of the gate after the completion of the project. In addition, because the energy dissipation of downstream energy dissipater is closely related to the operation mode of gate, the energy dissipation effect of downstream energy dissipater will be studied at the same time to verify the rationality of the original design scheme and provide reference for engineering design.

Under all working conditions, the outlet flow is free, and the head of hydraulic jump does not contact the bottom edge of radial gate, which will not endanger the safety of the gate. When opening the same number of holes, the flow pattern in the lock chamber and stilling basin with small opening degree is better than that under the condition of large opening degree.

Taking a sluice gate as an example, the discharge coefficient of sluice outlet under various working conditions is shown in Table 1. When the upstream reservoir water level is kept constant and the number of opening holes is fixed, the discharge coefficient of sluice outlet decreases with the increase of gate opening, and its value is between 0.653 and 0.710.

Table 1 Flow coefficient under various conditions

| Number of opening holes | opening degree (m) | upstream water level (m) | unit width discharge (m³/s/m) | total discharge (m³/s) | e/H | discharge coefficient |
|------------------------|--------------------|--------------------------|-------------------------------|------------------------|-----|-----------------------|
| 5                      | 1                  | 505.00                   | 20.00                         | 1184.6                 | 0.06| 0.710                 |
|                        | 2                  | 505.00                   | 23.00                         | 2059.5                 | 0.11| 0.687                 |
|                        | 4                  | 505.00                   | 26.67                         | 3548.8                 | 0.22| 0.672                 |
|                        | 6                  | 505.00                   | 30.38                         | 5200.2                 | 0.33| 0.653                 |

5. Summary

In the construction of large-scale hydro junction project, the overflow capacity of discharge structure, gate type, shape optimization and layout of downstream energy dissipators are very important in the project construction [5]. At present, there is no mature theoretical method to fully simulate, usually with the help of section physical model test, which requires high accuracy of the model. It has been proved by practice. The cross-section model test can better simulate the type of sluice, flow characteristics and the stability of energy dissipator, which can provide the basis for engineering design.

From the perspective of hydraulic conditions and energy dissipation effect, the hydraulic conditions and energy dissipation effect of flat gate and radial gate are basically the same. However, considering that the project needs regular flood control and pre discharge, and local opening is frequent, radial gate has great advantages in reducing the potential risk of gate vibration and cavitation, and the construction process and construction period are better than that of flat gate, The fourth scheme is selected as the recommended scheme.

Reference

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