Study on the Model Test of Yuliang Hydro-junction Closure Construction

Juntao Li
Key Laboratory of Engineering Sediment, Ministry of Transport, Tianjin Research Institute for Water Transport Engineering, Tianjin, 300456, China
lijuntao2005@163.com

Abstract. After studying and observing the hydraulic characteristics under different closure gap widths, the changes of various hydraulic factors, the rationality of the embankment zoning and dumped particle size, by simulating the whole closure process of the Yuliang Hydro-junction Project, a 1:100 overall hydraulic model test is adopted in this paper to put forward the scheme which is beneficial to the project closure, and provide scientific basis for construction organization design.

1. Introduction
The Yuliang Hydro-junction is located in the lower reaches of the Youjiang River in Guangxi. It consists of barrage, power station, and 1,000-ton ship lock and other buildings. Its total storage capacity is 6.11 million m³, and the normal water storage level is 99.50 m, the navigation standard of the ship lock is the Class III, channel navigation 2×1000t push fleet and the 1000t cargo ship, the hydropower station is equipped with 3 bulb tubular hydro-generator sets with a single unit capacity of 20MW, the total installed capacity is 60MW, and the rated net available head is 7m. The project layout is shown in Figure 1. According to the layout characteristics of the building, the project construction diversion is divided into two phases: the first phase includes the cofferdam construction of the left bank ship lock main body, the right bank power station and the 2-hole flood sluice gate, the diversion and navigation areas are the narrowed left side riverbed; the 7-hole sluice gate on the right side of the second-phase project will be diverted by navigation from the 2-hole sluice gate completed in the first phase, and the ship navigation will be undertaken by the completed ship lock. This paper mainly experimentally studies the hydraulic characteristics of closure gap during the closure of the second phase of the project, and provides scientific basis for the construction organization design.

Figure 1. Layout plan of Yuliang Hydro-junction Project.
2. Phase II closure construction plan

2.1. Closure method
The second-phase closure method adopts the upstream single-peak embankment to block the occupation, and the intercepting embankment is the upper part of the cofferdam, which is arranged on the backwater side of the cofferdam. The axis of the upstream embankment is arranged in a straight line, parallel to the axis of the cofferdam, and the distance between the two axes is 8.55 m. The embankment section is designed as a trapezoid, the upstream slope is 1:1.4, the downstream slope is 1:1.5, the top elevation of the embankment is 94 m, and the top width of the embankment is 9.0 m. With the closure of the embankment, the anti-seepage and cofferdam construction of the waterfront is carried out. The layout of the phase II embankment intercepting is shown in Figure 2.

![Figure 2. Plane layout of the phase II closure embankment](image)

2.2. Intercept flow and water level
According to the relevant data of the construction organization design, the flow rate of the river channel is 500m$^3$/s and 371m$^3$/s when the river is intercepted. The water level of the two flow-level dams is 90.03m and 89.59m respectively.

2.3. Closing materials and strength
According to different closure flow rates, closing materials with different particle sizes are used. When the flow rate is 500m$^3$/s, the closing materials are sand pebbles, stone blocks with particle sizes of 30~40 cm and 40~102 cm respectively, and steel stone-gabion with weights of 2t, 3t, 4t and 4.5t; when the flow rate is 371m$^3$/s, the closing materials are sand pebbles, stone blocks with particle sizes of 30~40cm and 40~90cm, and steel stone-gabion with weights of 1.5t, 2t, 2.5t, 3t. The specific gravity of the local stone is 2.67~2.7t/m, and the closing material strength is controlled by 10m$^3$/min.

3. The embankment zoning and rationality test of dumped particle size
The natural sands and stones with a specific gravity of 2.6~2.8g/cm$^3$ were selected as the closing stone particles for the test, the size of the model was selected after conversion according to the model scale, and the test was conducted according to the designed closing material strength and the model similarity criterion. After the closing material is thrown according to the design and occupation process, if the closing material flows out of the bottom slope of the embankment due to the effect of rolling and water flow, it is considered that the closing material starts to lose, then the second group of stones shall be thrown by that analogy, until it is closed$^{[1,2]}$. See Table 1 for the embankment zoning and closing particle size.

The test shows that under the two intercepting flow rates, the throwing is thrown according to the designed occupation process, and the throwing is basically not lost. When the intercepting flow rate Q=500m$^3$/s, firstly, the sand pebbles with a particle size of less than 25cm and the small stones with a
particle size of 30~40cm are thrown in the pre-intake section of 52m, and there is no loss of the throwing; as the width of the Closure gap is narrowed, the Closure gap flow rate increases, and the corresponding throwing particle size increases accordingly. The throwing material used in the 82~72m section of the Closure gap is the large stone with a particle size of 40~90cm, and there is no loss of the throwing material; the last 29m closed section is intercepted by a 4.5t reinforced steel stone-gabion, and the throwing material is basically not lost during the intercepting process. This shows that the design of the embankment zoning and the throwing particle size of the intercepting scheme are reasonable.

Table 1. Embankment zoning and closing particle size

| closing particle size (cm) | Occupation length (m) | Closure gap width (m) | Dumping quantity (m³) | Trips (vehicle) | Occupation time (h) |
|----------------------------|-----------------------|-----------------------|-----------------------|----------------|-------------------|
| <25cm                      | 0~34                  | 4641                  | 464                   | 7.74           |                   |
| 30~40cm                    | 34~52                 | 4101                  | 410                   | 6.84           |                   |
| 30~40cm                    | 52~64                 | 94~82                 | 3024                  | 302            | 5.04              |
| 40~102(90)cm               | 64~74                 | 82~72                 | 2184                  | 218            | 3.64              |
| 2(1.5)t Reinforced concrete stone cage | 74~97 | 72~49 | 5023 | 502 | 8.37 |
| 3(2)t Reinforced concrete stone cage | 97~107 | 49~39 | 1974 | 197 | 3.29 |
| 4(2.5)t Reinforced concrete stone cage | 107~117 | 39~29 | 1584 | 158 | 2.64 |
| 4.5(3)t Reinforced concrete stone cage | 117~146 | 29~0 | 4595 | 460 | 7.66 |
| Total                      | 146                   | 94                    | 27126                 | 2712.6         | 45.21             |

4. Analysis on the change of hydraulic parameters of closure gap

The hydraulic parameters such as the closure gap flow rate, the upstream and downstream water level, the maximum flow velocity of the closure gap axis, the drop width, the single width flow rate and the single width energy measured in the test are shown in Table 2 and Table 3.

It can be seen from the table, the closure gap hydraulic parameters have the following characteristics [3-5].

- As the width of the closure gap decreases, the upstream water level of the closure gap gradually increases, under the intercept flow rate is 500 m³/s, when the closure gap width is 94 m, the upstream water level of the closure gap is 90.46 m, and the closure gap width is narrowed to 29 m, the upstream water level of the closure gap increased to 91.68 m, and the upstream water level was 92.6 m after the closure gap was closed;

- The closure gap over-flow decreases with the decrease of the closure gap width, while the closure gap single-width flow increases with the decrease of the closure gap width. When the intercept flow rate is 500m³/s, the closure gap width is 94m, the closure gap overflow is 341m³/s, and the corresponding single width flow is 3.87m³/s. m, as the embankment is occupied, the closure gap is reduced to 212m³/s when the closure gap is 29m, and the single-wide flow of the closure gap increases to 8.95m³/s. m;

- As the width of the closure gap narrows, the water level change downstream of the closure gap is not very large, but the closure gap water level difference increases significantly. When the intercept flow rate Q=500m³/s, the closure gap width narrows from 94m to 29m, the closure gap water level drop increased from 0.32 m to 1.65 m. While the closure gap was closed, the upstream and downstream water level difference was 2.52 m.

Table 2. Hydraulics index of the closure gap (Q=500m³/s)

| Category | Unit | Closure gap width at the axis of upstream closure embankment (m) |
|----------|------|---------------------------------------------------------------|
| Upstream water level | m | 90.46 90.61 90.77 91.12 91.29 91.68 92.6 |
5. The hydraulic characteristics analysis of closure gap

- The embankment is blocked into a narrow stream of water movement. At any stage, the water flow is unconstrained;
- During the closure, the closure gap water flow shrinks, as the width of the closure gap shrinks, the contraction water flow shrinkage rate gradually increases, and the water flow curvature around the dam is gradually increased, and the closure gap water level difference increases;
- During the closure process, the closure gap water flow rate increases as the closure gap width decreases. When $Q=500 \text{ m}^3/\text{s}$, the closure gap width is narrowed from 94m to 29m, the corresponding maximum flow rate increases from 3.36m/s to 5.62m/s; when $Q=371 \text{ m}^3/\text{s}$, the corresponding maximum flow rate is 3.17m/s increased to 5.41m/s.

6. Conclusions

- When the project closure is completed, the flow through the closure gap is large. When the closure gap is 29m, about 40% of the flow passes through the closure gap. Under the intercept flow of 500 m$^3$/s, while the closure gap width is 29 m, the closure gap flow rate is mostly above 5.0 m/s, so the intercepting project has the characteristics of large closure gap flow rate.
- The water depth of the intercepting project is not very large, and the maximum water depth is not more than 5.0m. Therefore, increasing the strength of the throwing may be beneficial to the closure. At the same time, it is also considered to adopt the ladder-like shape for the top of the embankment, for a certain distance. That is, within a certain distance of the end of the...
embankment, the elevation of the top of the embankment can be advanced as long as it is higher than the current upstream water level by about 1 m. As the water level rises, the subsequent filling is generally thrown to the 94 m elevation. This kind of throwing method is used to improve the throwing intensity; on the other hand, it can reduce the amount of large stones.

- The roughness of the riverbed at the bottom of the embankment has a great influence on the loss of the throwing material, therefore, the roughness of the bottom protection stone should be increased as much as possible. Methods such as the uneven or reinforced steel stone-gabion protruding on the surface of the reinforced stone-gabion shall be adopted to facilitate the stop and stability of throwing stones.

References

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