Construction Technology of 1# Adit of Renzonghai Reservoir Power Station

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Abstract. Through analysing the geological conditions of the 1# Adit of Renzhonghai Reservoir Power Station, this paper proposed the control of blasting parameters, method of ignition and specific excavation methods under different conditions after describing the construction methods and supporting measures, which has certain reference value for excavation and support of tunnel.

Key words: open cut; temporary support; burden line of least resistance; wire mesh.

1. General situation of the project

Renzonghai Reservoir Power Station mainly consists of the dam hub, water diversion systems, plant hubs and "Yin Tian Ru Huan" water transfer hub. The Renzonghai water diversion project named "Yin Tian Ru Huan" belongs to RC I, and the work included the construction of several building projects, such as the project of grid bar and the joint dam of left and right bank, the project of scouring sluice, gravel pool, desilting channel and open channels for water diversion, project of the outlet tunnel (Stake No.: 0+000.000~6+900.000), etc.

The working face of the 1# Adit is mainly responsible for the construction task of the water transfer tunnel (1+500~3+900). The total length is 635m and the section size was based on the construction schedule. In order to speed up the construction progress, the original excavation section 4.4*4.4m (width * height) was changed to a 5*6m (width * height) city-gate type.

2. The location situation of 1# Adit situation

According to the design documents, the surrounding rocks are mainly Class II and Class III, having cave-forming conditions. From the perspective of the rock formations around the tunnel portal, the slope was stable overall and local instability may occur during excavation. In addition, due to the abundant groundwater in the area, it was expected that a large amount of seepage may appear during the construction of the tunnel, and therefore engineering treatments and drainage measures for the foundation pits shall be adopted.

3. Construction Procedures and Methods

3.1. Construction Procedures

Survey and staking-out was applied to determine the location of the tunnel portal first. The open-cut of earth and stone in the cave was completed at the beginning of June 2005; the safety support of the face-locking section was completed before June 15, 2005 and the cultivation of the adit was completed in mid-November 2005.Temporary support was applied depending on the stability of the surrounding rock in the excavation process.

3.2. Construction Methods

3.2.1. Open Cut of the tunnel portal. The open cut of the tunnel portal was conducted from top to bottom. The excavator was used for direct excavation, supplemented by artificial slope cutting, and the method of drilling and blasting the rock with hand drill was performed. Stone ballast was transported by the excavator with a 5T dump truck to the ballast field B 300m away.

The excavation of the tunnel portal slopes should be accompanied by safety precautions. The method of the concreting-bolting support was applied for slope protection, anchor rods using mortar; the anchor rod adopted grouted rock bolt and secondary deformed bar Φ22, L=3.0m.

*3.2.2. Stonework excavating from tunne*l. (1) Survey and staking-out A total station was used to determine the center of the tunnel for the build-in of foundation pile and then the original topographic map was mapped. (2) Muck removal in construction the 2t dump truck directly loaded by the ZL40 loader transported ballast to the ballast field B. (3) Drilling and blasting design The tunnel of the adit was excavated using smooth blasting and the full-section realized one-off excavation. The footage driving cycle of excavation was 2m, with an average of 2 cycles per day and footage of 120m per month. (4) Blast hole layout

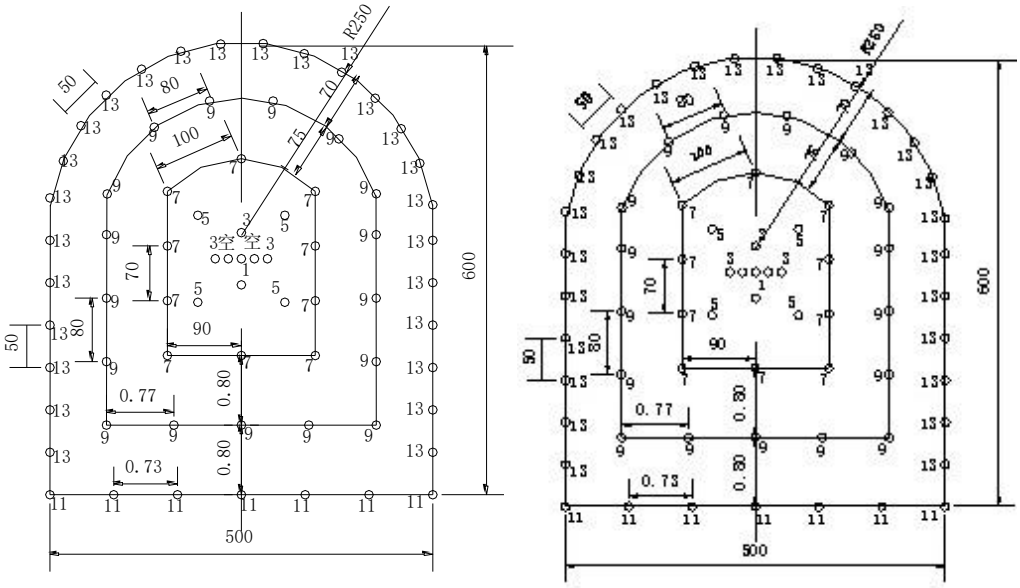

Figure 1. Diagram of borehole layout

(5) Selection of blasting parameters

According to the analogy method, combined with construction experience of our company in the same area, the blasting parameters to be selected are shown in Table 1.

Table 1. Blasting parameters of the adit

No.	Blasthole name	Blasthole		Millisecond detonator		Single-hole drug roll				Total (kg)
						Φ25		Φ32		
		Depth (m)	Amount (piece)	Zone segment (segment)	Amount (piece)	Number of sections	Weight (kg)	Number of sections	Weight (kg)	
1	Slot hole	2.8	5	1, 3	5			10	1.50	7.50
2	Air hole	2.8	2							
4	Auxiliary eye	2.7	22	7, 9	22			9	1.35	29.70
5	Inner track eye	2.7	4	5	4			9	1.35	18.70
6	Smooth blasting eye	2.7	21	13	21	4	0.40	1	0.15	11.55
7	Bottom eye	2.7	7	11	7			9	1.35	9.45
Connection				1	5					
Total		154.6	57		62	84	8.40	332	55.20	63.60
Description		The Smooth blasting hole uses Φ42 drill bit and the remaining holes use Φ38 drill bit. The non-electricity detonation detonator was used for detonation, with a length of 5m and a unit consumption of 1.33kg/m^3.								

(6) Blasting network

The detonating network of non-electrical detonation detonator was adopted. The points outside these holes were connected with mS1 detonators. The detonation sequence is shown in Figure 2

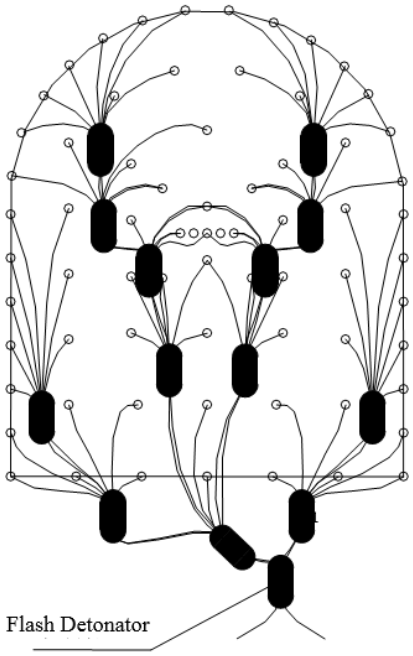

Figure 2. Detonation network schematic

3.3. Temporary support for tunnel trunk
During the excavation process, anchor rods, concrete, steel fabric and grille arches were used for temporary support according to the geological conditions to ensure the stability of the surrounding rock in the cave.

3.3.1. Protection by spraying the construction of spraying concrete adopted the wet spray method. The materials used should meet the industry standards, and the cement mark should not lower than 425#; the fine aggregate was made of durable rough coarse sand with a fineness modulus greater than 2.5, sieved with a 5mm sieve. Particles larger than 5mm and smaller than 0.075mm shall not exceed 20%, and the moisture content shall be controlled at 6%; the coarse aggregate should be made of pebbles or gravel with a hard and durable texture. The particle size should not exceed 15 mm and the aggregate should not contain SiO2. The mix ratio of sprayed concrete should be determined experimentally.

The concrete was pushed to the work surface manually after being transported from the mixing station to the mouth of the tunnel by the tanker truck. Worker sprayed with the ZPS-2B injection machine on a simple platform, from the bottom to top, from the side wall to the roof. It is needed to apply high-pressure blast and high-pressure water to flush the rock before spraying.

3.3.2. Anchor rods. The construction of the anchor rod adopted the YT-28 air-leg type pneumatic drill which was used to drill on a simple platform manually. After being processed in the reinforcing steel workshop, anchor rods were transported by 5t dump trucks to the entrance of the tunnel and then transported manually to the construction work surface. Anchor eyes must be washed before the mortar anchor rods were poured. Knocking, collision and pulling of the anchor rods were prohibited until the mortar had solidified.

3.3.3. Grille arch centering. The site where the grille arch centering would be erected was determined according to the geological conditions. According to the type of the excavation section, the arch centering was processed in the reinforcing steel workshop and transported to the construction site for manual assembly. During the assembly process, measurements should be made to ensure that the grille arch centering did not occupy the design section. And at the same time, the arch centering should be placed close to the rock face and welded together with the accessories to prevent loosening.

*3.3.4. Hanging Nets.*Steel fabric should be lay at designated locations before shotcrete. After the steel fabric was processed into a small piece of φ6@20×20 cm in the workshop, it was transported to the site and attached closely on the rock surface with a simple platform, and then was fixed on anchor rods. Concrete should be sprayed timely after the steel fabric was hanged.

4. Treatment of adverse geological sections
For the collapsed sections, excavation shall be carried out using the construction method of “short footage, weak blasting and strong support”, and anchor rods and steel support shall be used in time. For abnormal situations such as water inflows, emergency measures should be taken and additional drainage systems should be provided to drain the water. For sections with big and hard rock deeply buried in the tunnel, rock burst may occur. They should be closely observed and highly valued during construction. When necessary, some security measures can be implemented, such as watering the breast, attaching 100X100 steel fabric compiled by Φ20 to the rock face, retaining and protecting.

5. Conclusion and recommendation
(1) As far as this project is concerned, the blasting parameters used are reasonable and the results meet the design requirements.

(2) In the construction of 1# Adit, the operation process of blasting design, measuring and setting-out, drilling and charging were strictly conducted according to the specifications; and the control and management of the construction process were also strengthened to obtain good results.

(3) Tunnel construction in similar geological conditions can use the construction process and parameters of this project for reference, and adjustment should be applied according to actual geological conditions and field tests of design standards.

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