Excavation and support construction of rock wall crane beam layer in underground powerhouse of a pumped storage power station

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Abstract. Rock wall crane beam construction is the focus and difficulty of underground powerhouse construction. The quality of its excavation molding will directly affect the operation safety of the plant bridge crane. This article introduces the excavation procedure of rock wall crane beam for the underground powerhouse system engineering of a pumped storage power station And method, anchor rod construction, net hanging, and spraying construction have achieved good results, and have certain reference value for excavation and support construction of rock wall crane beams in similar projects.

Keywords: Rock platform; duct; sample frame; anchor.

1. Introduction
The main building of a pumped storage power station is composed of 4 parts: a water transmission engineering system, a power generation engineering plant system, an upper reservoir and a lower reservoir. The power plant is an underground plant, consisting of the main plant and the auxiliary plant. The installation room is arranged on the right side of the main plant (in the direction of current generation, the same applies hereinafter); the auxiliary building is arranged on the left side of the main room. The total excavation length of the main plant cavern is 176.25m, and the rock wall crane beam is used in the plant. The excavation span above the rock wall crane beam is 28.30m, the following is 26.50m, and the maximum excavation height of the plant is 58.370m. The typical cross-section excavation size between main engines is 105.02m×26.5m×55.07m (length×width×height), and the typical cross-section excavation size of the auxiliary plant is 27.18m×26.5m×50.9m (length×width×height). Installation site the excavation size of a typical section is 44.05m×26.5m×25.17m (length×width×height) [1-3].

2. Engineering geological conditions
The mountain area in the plant layout area is strong, the lithology is medium-grain biotite granite, and the overburden body on the top arch of the plant is about 330m thick. The rock mass in the factory area is good, the surrounding rock in the cave is fresh, the average RQD value of the borehole is greater than 95%; the acoustic wave velocity Vp of the borehole is 5560m / s ~ 6450m / s, which is a complete rock mass; the uniaxial saturated compressive strength of the rock is greater than 70MPa, Belongs to the hard rock category. A total of 2 small faults were discovered in the exploration branch caves, with a fracture breaking bandwidth of 0.4m~0.6m. The rocks in the zone were broken and muddy, poorly cemented or not cemented, and there was a small amount of water seepage. There were 24 rock veins, mainly in two groups[4-6]: ①80°~90° /SE ~ S ∠ 80° ~ 85° ；②280° ~ 310° /SW or NE ∠ 75° ~ 85° . Diorite
veins range from 0.05m to 1.4m in width, most of them are in close contact with granite on both sides, and a small part of the contact surface is sandwiched by muddy objects with a width of 0.2cm to 1cm. The most developed joints are mainly the following two groups: ① E/S or N∠75° ~ 90°; ② 310° ~320° /SW or NE∠80° ~ 85°. Structural surfaces such as joints are mildly developed, closed, and small in length [7-9].

The cave rock in the factory area is mainly type II, accounting for about 77.5%; the local vein development section belongs to type IV rock, accounting for 22.5% [10].

3. Plant excavation
The main factory building is excavated in layers. The rock wall crane beam is located in the third layer (the third layer is the rock wall crane beam layer, the same applies hereinafter) [11, 12].

3.1. Construction Program
Excavation and support of the rock wall crane beam is carried out following the middle slot drawing. Construction procedure of single-section rock wall crane beam: light burst hole drilling, PVC pipe insertion, plugging of openings on the upright wall→rock platform protection layer III1→excavation of central slot III2→excavation of central slot III3→rock platform Protective layer III4→Protective layer III5→Geological sketch and acceptance of rock surface foundations→Supporting construction of layer III→Implementation of reinforcement measures at the inflection point→Drilling of oblique light explosion holes on the rock platform→Construction of pre-fracture in the middle of the fourth layer (Blasting), pre-splitting around the fourth layer in turn in advance → bidirectional light explosion of rock platform triangle (zone III6)→rock platform tension and compression anchor construction → concrete construction of rock wall beam→upper wall of rock wall beam III Spray concrete spray.

3.2. Excavation of hierarchical partitions
The excavation layered elevation of the thin layer on the rock wall crane beam layer of the powerhouse is determined to be EL.342.870m ~ EL.338.870m, and the excavation height is 4.0m. The upper thin layer excavation is divided into two areas: the central horizontal advanced excavation area and the reserved protective layer lagging excavation area. The central horizontal advanced excavation section size is 20.3 × 4.0m, which is excavated in about half of the left and right. Dimension is 3.1×2.6m. The layered excavation of the lower layer of the third layer of the factory building is determined to be EL.338.870m ~ EL.335.270m, and the excavation height of the lower layer is 3.6m. The lower thin layer excavation is divided into 2 areas: the central horizontal advanced excavation area and the reserved protective layer excavation area. The central horizontal slotted section size is 20.3 × 3.6m, which is excavated in left and right half. The protective layer section size is 3.1 × 5.0m, the reserved rock platform is scheduled to be excavated in the third phase, and the size of the rock platform triangle is 0.9 × 3.69m. The construction aisle enters from the ventilation tunnel and the traffic tunnel into the factory at a 12% drop.

See Figure 1 for the layered excavation procedure for rock platform excavation, and figure 2 for the Schematic diagram of rock platform excavation.
Figure 2. Schematic diagram of rock platform excavation

3.3. Excavation method

After the protection of the second floor of the factory building is completed, the construction of the groove in the middle of the rock wall crane beam layer is performed. A 4m protective layer is reserved outside the straight wall below the downstream side wall (the specific thickness of the protective layer is determined by blasting tests during the implementation process) as the second phase of excavation. The smooth layer blasting is used between the protective layer and the triangular rock mass. Phase III excavation.

According to the structural characteristics, passage conditions, construction quality requirements, and construction technology points of the underground partition of the underground powerhouse, the excavation construction procedures and construction methods for the third floor of the powerhouse are shown in Table 1.

Table 1. Excavation construction procedures and methods for the third floor of the factory building

| Part       | Elevation / layer height (m) | Construction aisle | Construction procedures and methods |
|------------|-----------------------------|-------------------|------------------------------------|
| Upper layer| 342.87m ~ 338.87m/4.0m      | Enter the floor of the excavation surface of the plant through the ventilation tunnel through the left end of the plant | The upper thin layer is excavated in advance by horizontal slotting in the left and right half of the middle. The two halves are synchronously constructed with a staggered distance of 30m, and the holes and slags are alternately operated. Protective layers on both sides are reserved for expansion and lagging. A row of horizontal light blasting holes is set between the middle trough and the protective layer. The vertical smooth surface blasting is used between the protective layer and the triangular rock platform. The rock platform triangle is excavated as a whole. The whole program excavation of the upper thin layer is followed up, and several processes in the plane are operated simultaneously. Before excavation of the upper thin protective layer, the smooth blast hole operation and auxiliary blast hole drilling operations on the part of the straight side wall on the rock platform triangle must be completed, and the PVC pipe is inserted to protect the hole. The upper thin layer is excavated in all areas by hand drills for horizontal excavation. The left and right half of the horizontal slot is excavated by smooth blasting and the blasting cycle is |
| Part                                      | Elevation / layer height (m) | Construction aisle                                                                 | Construction procedures and methods                                                                                                                                 |
|-------------------------------------------|-----------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lower thin layer and rock wall crane      | 338.87m~335.27m/3.6m        | Enter the floor of the excavation surface of the plant from the traffic tunnel through the right end of the plant | 4m. The protective layer is excavated by smooth blasting and the blasting cycle is 4.0m. After blasting, a backhoe excavator is used to deal with the related safety hazards. A 1.8m³ backhoe or a 3.0m³ side dump loader is used to transport the slag for excavation. |
|                                          |                             |                                                                                   | In the lower thin layer excavation, the left and right half of the horizontal pull slot are excavated ahead of time. The two halves have a 30m staggered synchronous construction and alternate drilling and slugging operations. Both sides of the protective layer are reserved for expansion and the lag is connected to the blasting zone with 1 to 2 rows of guns. A row of horizontal light explosion holes is added between the protective layers. Vertical smooth surface blasting is used between the protective layer and the rock platform triangle. In order to ensure the formation effect of rock platform excavation, it is recommended that after the protection layer is excavated, a row of C28 @ 800mm, L = 3.0m lock anchor bolts be set 20cm below the inflection point below the rock platform. A8 @ 200 × 200mm steel mesh is hung on the surface of the anchor rod and within 1m below, and the initial sprayed C25 concrete is 50mm thick. After the support is completed, the rock platform excavation operation is performed, and finally the rock platform anchor rod construction and concrete pouring and curing are performed. The excavation and support of the thin protective layer under the lagging of rock platform triangle blasting is 30m. Follow-up excavation of the whole thin layer excavation is followed by programmatically, forming multiple operations in a plane at the same time. Excavation of hand-drilled holes in all areas of the lower thin layer, full-section blasting excavation, circular footage 4.0m; triangular rock platform excavation construction scheme: smooth blasting holes on the rock wall crane beam above the inflection point of the straight wall design contour, manual It is made by wind drilling, laying PVC pipe and plugging nozzle protection. Rock wall crane beam excavation of small triangular body rock platform adopts triangular body inclined wall surface and upright wall surface hand drill to drill oblique hole and vertical hole bidirectional smooth blasting. 1.5 inch steel pipe is used for drilling to set up steel pipe sample frame and guide pipe (such as Figure 2) Drilling construction accuracy control is performed. The distance between the two sides of the rock platform for smooth blasting holes is 40cm. On the elevation, the vertical holes of the rock platform and the oblique holes and the vertical light blasting holes of the lower protective layer form a straight line. Use special small-diameter medicine roll bamboo strips for lashing, space charging, magnetic explosion detonator detonation, detonation index explosion, and one blasting length of rock platform is not more than 20m. After blasting, a backhoe excavator is used to deal with the related safety hazards. A 1.8m³ backhoe or a 3.0m³ side dump loader is used to transport the slag for excavation. |
Figure 3. Steel pipe rack and guide pipe
After blasting excavation, the effect is good, as shown in Figure 3.

Figure 4. Effect of blasting excavation

4. Support construction
The excavation span of the underground powerhouse cavern is large, and the stability problem of the side wall is prominent. During the excavation of the factory building, timely support should be carried out in strict accordance with the requirements of the design and supervision personnel to form a flowing process construction. After the excavation of the workshop is completed, it shall be supported with relevant supporting measures in time to ensure safety and quality. A three-arm rock drilling trolley is used for anchor bolt construction to make holes. The grouting is performed by Meister and FCB-250 grouting machine, and the concrete spraying trolley is used for wet spraying. The support of type II surrounding rock and type III surrounding rock can be lagged behind the palm face by 10m ~ 15m, 5m ~ 10m, respectively, and the support of type IV surrounding rock must follow the palm face. During the excavation of the guide hole at the bottom of the factory building, if it encounters unstable rock formations, temporary support should be taken immediately.

4.1. Mortar anchor construction
The main types of mortar bolts for the rock wall crane beam layer system of the powerhouse are C25, L=5m/7m, C28, L =7m/9m, C32, L =9m. According to the type of surrounding rock and structural requirements, the system anchors are in plum blossoms Shape arrangement, the interval is mainly 1.2m or 1.5m. Lock bolts and anchors that may intersect at the tunnel crossing should be staggered from each other. See Figure 4 for anchor construction procedures.
4.2. Net hanging and spraying construction
The support method of the crane beam layer of the rock wall of the factory building is a hanging steel mesh A8 @ 200mm × 200mm, and the thickness of the sprayed C25 concrete is 150mm (the initial spray is 5cm). A12 stand bars are set in the hanging net area, and the spacing between the stand bars is the same as that between the anchor rods at the corresponding position. Generally, the distance between hanging net and rock surface is about 3~5cm. Stand bars, net bars, etc. are disconnected from the scene when they encounter holes. The process frame of spraying concrete construction is shown in Figure 5.

5. Conclusion
The rock wall crane beam layer excavation and support construction effect of this project is good, and they can meet the relevant requirements. The summary experience is as follows:
(1) Rock platform construction is the key to rock wall crane beam construction. After the test, it is necessary to select the two-way light explosion parameters of the rock platform triangle, and adjust the charging parameters according to different geological structure rock layers. Before excavation of the rock platform triangle, a row of ordinary mortar anchors (0.5m spacing) was added 20cm below the

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**Figure 5.** Construction procedure chart of anchor rod

**Figure 6.** Flow chart of spraying construction
infection point, and bad geological structures such as small faults and fissure zones, as well as bad geological structural surface combinations, were hung with steel bars before the triangle blasting.

(2) Perform excavation blasting tests in the excavation area of the installation site before excavation, and obtain reasonable blasting parameters and construction techniques (such as sample frame erection, drilling angle and depth control, inclined hole opening process, etc.). Excavation of rock wall crane beams.

(3) After the excavation of the outer protective layer, a steel pipe sample frame is set up from the lower part, and a hand drill is used to drill the light blast hole of the rock platform obliquely upward from the lower part, and the embedded PVC pipe is used to protect the hole formation to ensure drilling accuracy.

In summary: The excavation and support construction of the rock wall crane beam layer of this project provides experience and guidance for the excavation and support of the rock wall crane beam layer of similar projects.

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