Several rock mechanics problems and countermeasures in deep-buried caverns of hydropower project

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Many deep-buried caverns are designed in China's hydropower project, and rock mass of which are usually in high ground stress conditions. Strong excavation unloading and complicated geological conditions induce complexity of mechanical properties of rock mass, as well as diversity of rock mass failure types, which result in huge challenges for construction, normal support measures may not meet the requirements for stability. This paper puts forward several rock mechanics problems and countermeasures in powerhouses of Baihetan and deep-buried long tunnels in Jinping II.

Baihetan hydropower station is located in lower reaches of Jinsha River, which is the biggest hydropower station under construction in the world at present. Concrete hyperbolic arch dam is 289.0m high maximum, with the installed capacity of 16000MW, including 8 Francis turbine generators of 1000MW respectively. There developed several disturbed belts and columnar joints in basalt rock mass of powerhouse site, and the maximum ground stress is up to 33MPa. Therefore, both of the discontinuity and stress controlled instability problems occurred in the project, and the problem seems more serious when the columnar joints basalt under high ground stress, which is closely related to the cavern size, span and height. After rock deformation analysis, this paper puts forward the support requirements of systematicness (cooperative work of several support measures), timeliness and pertinence, blasting control, monitoring and detection (deformation, stress and relaxation depth), and corresponding countermeasures.

Jinping II hydropower station with the installed capacity of 4800MW. The four diversion tunnels, approximately 17km each, are generally buried in the depth of 1000~1500m and even up to 2525m. The hydraulic tunnels of this project is largest in scale, most comprehensive difficulty, highest ground stress (up to 100MPa), highest external water pressure (up to 10MPa) all over the world. Due to the deep buried depth and high ground stress, 50% of the tunnel sections occurred high stress failure, and more than 1000 times rock burst, and 111 times in which are severe to extremely severe. The excavated ground water has some special characteristics, including high external water pressure, large discharge, highly exchange, abruptness, etc. And the maximum external water pressure attained is 10MPa. In order to provide initial data for the rock mass stability analysis, several new measures are conducted or invented, including stress testing system of ultra-high pressure hydraulic fracturing (fracturing pressure up to 94.97MPa, maximum horizontal principal stress up to 113.87MPa), deep buried brittle rock nondestructive sampling technology, rock mass classification system under deep-buried and high external water pressure. And several support measures are adopted in this project, including a method of dynamic back-analysis of rock mass stability for deep-buried project, in-time support (Spray Nano concrete + water expansion bolt, maintain the ground pressure and prevent the fracture progress), raised shell pre-stressed bolt (take full advantage of the arch effect of the palm), system shot-bolting support system (strengthen the disturbed zone). In order to guarantee the long term safety for the hydraulic tunnels, the surrounding rock is considered to be the major bearing subject, and bolting and shot Crete support system, reinforced concrete lining and high pressure consolidation grouting measures are conducted to enhance the surrounding rock also, therefore, the rock mass and the support system become a unified complex and a complex bearing structure, by external water pressure release technology (Drainage drift + relief hole). The monitor results indicates that the operation situation of the project is well.