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Design of Large Parallel Underground Openings in Himalayas: A Case Study of Desilting Chambers for Punatsangchhu-I, Bhutan

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Abstract : Construction of a single underground structure is itself a challenging task, and it becomes more critical in tectonically active young mountains such as the Himalayas which are highly anisotropic. The Himalayan geology mostly comprises of incompetent and sheared rock mass in addition to fold/faults, rock burst, and water ingress. Underground tunnels form the most essential and important structure in run-of-river hydroelectric projects. Punatsangchhu I hydroelectric project (PHEP-I), Bhutan (1200 MW) is a run-of-river scheme which has four parallel underground desilting chambers. The Punatsangchhu River carries a large quantity of silt load during monsoon season. Desilting chambers were provided to remove the silt particles of size greater than and equal to 0.2 mm with 90% efficiency, thereby minimizing the rate of damage to turbines. These chambers are 330 m long, 18 m wide at the center and 23.87 m high, with a 5.87 m hopper portion. The geology of desilting chambers was known from an exploratory drift which exposed low dipping foliation joint and six joint sets. The RMR and Q value in this reach varied from 40 to 60 and 1 to 6 respectively. This paper describes different rock engineering principles undertaken for safe excavation and rock support of the moderately jointed, blocky and thinly foliated biotite gneiss. For the design of rock support system of desilting chambers, empirical and numerical analysis was adopted. Finite element analysis was carried out for cavern design and finalization of pillar width using Phase2. Phase2 is a powerful tool for simulation of stage-wise excavation with simultaneous provision of support system. As the geology of the region had 7 sets of joints, in addition to FEM based approach, safety factors for potentially unstable wedges were checked using UnWedge. The final support recommendations were based on continuous face mapping, numerical modelling, empirical calculations, and practical experiences.

Keywords : dam siltation, Himalayan geology, hydropower, rock support, numerical modelling
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