Geotechnical Problems Encountered in the Penstock and Power House Components of Kuttiyadi Additional Extension Scheme, Kozhikode District, Kerala.

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Abstract

Introduction

Kuttiyadi Additional Extension Scheme (KAES) is proposed for enhancing the installed capacity of the existing Kuttiyadi Hydro Electric Project (125MW) at Kakkayam by 100MW (2x50MW) due to the availability of additional water supply from Karaman Thodu Reservoir of Kuttiyadi Augmentation Scheme. The KAES Scheme is implemented by constructing an Intake in the Kakkayam reservoir, a Power House beside the existing (1x50MW) Kuttiyadi Extension Scheme, a water conductor system consisting of 684m tunnel and 2115m long penstock. The available hydraulic head is 666m. Construction stage geotechnical investigations, and the geological problems encountered in the penstock track and power house site are described in this paper.

Geology of project site

The Kuttiyadi project area is made up of hills with a few deep and narrow valleys. Outcrops are scarce or seen in hill tops. Near the Intake, surge, and at the middle of penstock route weathered rock outcrops are seen. Other areas are covered with thick over burden. A sub vertical doleritic dyke is seen at the penstock Anchor block-3 location. The excavations made for various components have exposed the underlying rock i.e fresh migmatitic gneiss with three to four prominent joints are common. The joints are rough, planar, tight with or without infilling. As the area receives copious rain, weathering of rock is pronounced due to which country rock is transformed in to a friable incoherent, loose material. Thick over burden and sub- horizontal weathered seams with in country rock are prominent at the power house site and terminal anchor block location.

Penstock

The proposed 2144m long penstock is to be located on the side slope of a ridge since, the ridge-top is occupied by the existing penstock pipe of the Kuttiyadi hydel project. GSI conducted preliminary investigations along the proposed penstock alignment (V.Balachandran-2001). The study indicated that along the penstock alignment weathering of the rocks remains pronounced due to which the depth of the over burden ranges from 4m to 26m. Hence GSI recommended the determination of bearing capacity of the materials for founding the anchors in overburden. The proposed alignment of penstock is to be located on the side slope of the ridge, hence stability considerations were raised by GSI, and recommended pressure shaft instead of Penstock. But, project authorities (KSEB) have preferred the surface penstock. Boreholes have been drilled on the anchor block locations and additional bore holes were also drilled in between anchor locations. The area is also slide prone with active and dormant slides and one slide (Konipara slide) took place even during construction and particularly the Anchor blocks 13 to 17 are located on the vulnerable slope.

The anchor block – 13 and 13A are proposed in the zone of accumulation of a palaeo slide. The slide debris material is unsorted comprising weathered, angular to sub angular rock blocks of varying sizes, clay, silt and sand sized particles. An erosional cave is reported to occur parallel to the direction of the slide. Though the slide is stabilised, the modification of the slope due to the construction activities may lead to instability. The depth to bed rock from the present level of excavation is about 19 m. Hence it was recommended to work out the possibility of relocating the Anchor block – 13 to the area upstream of the paleaoslide, where insitu weathered rock is exposed.
Just 25m D/S of 13A weathered rock with thin soil cover is seen. Anchor block 14 and 14A are located on rocky ridge and weathering is feeble to moderate. The slope forming material of anchor block location 15 (AB15) is made up of clayey silt, lateritic clay, micaceous and completely weathered rock (palaeo slide debris - though stabilized). Rubber plantations are there. The material has shown signs of distress and failed in the 2006 monsoon inspite of giving protection by geotextiles.

At Anchor Block 15 A location highly weathered rock is exposed on the left cut slope (where geotextiles is provided for slope stability) the overburden material is clayey.

The Anchor block location no.16 (AB-16) has 26 m of overburden consisting of boulder and slide debris. It is a paleo slide area (now stabilized) with assorted material which has potential for destabilization during monsoon. Already it collapsed during the 2005 monsoon and slush has flown in to powerhouse pit.

Excavation of about 15m depth made at the rear side of the proposed power house at the location of Anchor block no17 and upstream showed the presence of 8m thick litho margic clay and lateritic soil followed by moderately weathered rock of about 5 to 6m below which fresh rock is occurring. The litho margic clay when came into contact with water will become slush and induce failure of the slope on either side of penstock track. Already failure has started taking place at number of places and hence it is recommended to provide immediate support measures and berm at every 5 or 6m with slope cut of 1H and 1V at this location. The back slope of powerhouse above AB 16 A & 17 (particularly the right side) is to be eased and provided with berm as the medium is slide prone under saturated condition.

Hence in view of the above, it is recommended that at the location of the Anchor blocks 13, 15, 15A and 16 where the thickness of the overburden is high and old slide debris is predominant, it is to be ensured that the load of Anchor blocks is to be transferred to the insitu hard rock whose depth is inferred from bore hole so that the stability and safety of water conductor systems is ensured. In addition temporary slope protection measures are also to be provided during excavation.

Power House

A 2 x 50 MW powerhouse (third powerhouse in the Kuttiyadi Scheme with the size of 32.8X17.75m) under construction has been excavated progressively in the machine pit and column foundation areas. This additional powerhouse shares the left side columns with the existing powerhouse. The powerhouse area is occupied by the hornblende biotite migmatite gneiss with tight isoclinal folds and ptygmatic folds. The foliation trend in N50°W–S50°E direction with 55°dip towards N40°E direction. The sub-horizontal joints are predominant in the area with the strike of N20°E – S20°W direction with 15° to 20° dip towards N70°W direction (gentle dip towards downstream side or towards tailrace area) besides few steep dipping joints also noticed. These sub-horizontal joints are filled with weathered seams of 20cm to 70cm thickness and

numbers of sub-horizontal seams transect the fresh rock which acts as sheet in the entire powerhouse area from u/s to d/s. within the hard rock intermittently at various levels.
The weathered seams exposed on the walls of the Column pits and Machine pit areas show the differential weathering along the strike and dip direction resulting in non-uniform thickness from upstream to downstream direction. The intensity of weathering also varies from place to place. It's nature varies from close spaced fracturing to completely weathered rock and clayey soil. (The seam materials were of clay, sandy clay, and sand with rock particle etc (complex nature). These multiple weak zones may act as destabilizing factor in the column foundation considering the significant design load (nearly 1000 tonnes per SQm). Hence it has become essential to ascertain the exact depth and nature of weathered seams (below the design foundation level) and thickness, fresh rock in between the sub-surface seams, etc.

After studying bore hole cores (solid rock and loose materials) discussion was held with project authorities to arrive at the founding level of various column footings considering the geological nature of various strata and the maximum possible load and pressure that is expected to come under footing of various PH columns. To know the groutability and permeability of the weak strata at the elevation of the seam tests were conducted at select places. The results indicated that most of the seams took significant grout intake and post grout permeability was also low. After analysing all the data, founding levels of columns and necessary measures to improve and strengthen the weak strata underneath, such as consolidation grouting, were decided.

The Machine pit area has also indicated the presence of weathered seam at El. 80.23 M to 79.43 M. The nature of the weathered seam varies from rock pellets to rock powder and clayey silt. The bore hole, drilled earlier, and the two confirmatory bore holes carried out presently, established the presence of weathered seams at different levels in the foundation medium throughout the sub surface area of machine pits. In order to consolidate the rock mass and to overcome the unequal bearing capacity of different strata at the sub-surface of machine pits the following remedial measures were suggested. For the entire machine pit area, consolidation grouting, down to the El.76.00 M from the present floor level with 3 Mtrs spacing, which are staggered evenly, is to be carried out in 3 Mtr stages. Provision should be given for grouting by leaving pipes while laying the leveling course concrete. The foundation anchoring/bolting is to be

carried out to tie up or stitch the rock mass of weathered seams sandwiched between the fresh rocks to the fresh rock at a level of 8 M from the present floor level. The anchor rods of suitable thickness may be given in staggered fashion and grouted. In the machine pit area, each row should have minimum of 3 anchors with spacing of 3 Mtrs. The anchoring to be invariably done before pouring the leveling course concrete.

References:

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