THESIS

GROUND WATER CONTROL IN OPEN EXCAVATIONS

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Abstract

Malakand III Hydropower Project is with installed capacity of 81 MW is located near existing power station of Dargai Malakand Agency, NWFP, Pakistan. The project envisages the construction of a 40m deep pit to locate the power house with 3 units. Excavation slopes for Powerhouse at Malakand failed during excavation of the powerhouse pit due to high water table and / or excessive pore water pressure or steeper slopes.

The study aimed at investigating the role of controlling ground water and pore water pressures to stabilize the unsupported excavation slopes and proving the drainability of the proposed excavation slopes by adequate dewatering. The problem faced at Malakand was taken up, as a typical example in this study and comparative analysis were carried out.

The study objectives included determining the water table configuration with and without internal drains and well point dewatering system, establishing pore water pressures and stability relationships for unsupported excavation slopes for alternate dewatering arrangements. The study objectives were achieved by using computer software GeoStudio (SEEP/W and SLOPE/W packages) employing respective site specific hydro-geological and geo-technical data.

The material parameters and hydro-geo-technical data was obtained from the investigations carried out by the project consultants during 2002 (Original Design Phase) and again in 2004 (Post Failure Design Phase) after the slope failure had occurred. The results of all these investigations were reported and made available by CMTL.

A sectional model of the excavation slope was formulated by using SEEP/W. The model was calibrated by comparing the phreatic line computed from the model with the water level observations for 2002 (original slope configuration with no drainage measures adopted) and 2004 (revised slope with inclusion of combination of drainage measures) period. Various slope configuration and drainage measures (full drainage as proposed, no drainage and partial drainage were analyzed for both excavation profiles i.e. the Original Design Slope and the Post Failure Slope.

The excavation profile as described for the Original Design Slope with groundwater control defined by two wells and one drain indicates a 2m seepage face and a safe design with an acceptable factor of safety of 1.381. The same Excavation Profile without any groundwater control indicates a potentially unsafe design with a 6m seepage face and a factor of safety of 1.101, which is smaller than the recommended factor of safety of 1.25. However some professional considerations are tempted to evaluate temporary slope for a FOS ±1.00. The same Excavation Profile with limited groundwater control, considering only a single well or a single drain, still improved the factor of safety to a value of around 1.3. From the analyses it is evident that the slope failure occurred due to non provision of drainage measures.

The Revised Design (Post Failure) Slope indicated a factor of safety of 1.788, 1.32, 1.786 and 1.715 for conditions of full drainage (3 wells and 2 drains), no drainage and limited drainage i-e, one well or one drain respectively, providing a safe slope for all conditions. The increased factor of safety for the excavation profile of the Revised Design (Post Failure) Slope from the Original Design Slope for all conditions is primarily attributed to flatter slopes and smaller cut depths.

The slope instability threat as posed to be purely a ground water problem however may not be completely true. This stipulation can be perceived with the reasoning that the actual pit did not fail altogether instead the failure was partial towards the western slope only. The failure itself can therefore be defined same by additional factors other than ground water line erosion, temperature, in-situ stress, earthquake-induced loading and geometric boundaries imposed by the orientation, spacing and continuity of the joints, as well as the free surface boundaries imposed by the excavation itself.