THESIS

STUDY OF BENCHING PHENOMENON AT UPSTREAM SLOPE OF MANGLA DAM

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ABSTRACT

A dam failure may lead to lot of hazards like loss of life, property, agriculture and wastage of national money already spent on dam construction. It is better that the maintenance and repairs should be on regular intervals to avoid any hazard in future. The dam after its construction has to face wind action, regular striking of waves, earthquakes, settlement of foundation and disturbance in riprap. The upstream slope of the Mangla dam was protected by riprap during its construction against wave action. But after six years of completion of dam, it was observed in 1973 that riprap on upstream face of main embankment has slipped / dislodged at numerous places between elevation 1170 ft and 1195 ft. The treatments were carried out in different years. During 1977, 14000 ft^3 of small stones were added to repair benches. Secondly in years 1980 to 1983 about 54000 ft^3 of riprap was placed by manual labour to backfill more significant depressions. Third attempt was made in 1991 but did not prove satisfactory because in 1993 a more rapid draw down occurred and again benches were developed. No further attempts and studies were conducted in this regard. After rapid draw down in 1993 observed benches were typically about 5 ft to 20 ft wide and extended in length from 20 ft to over 100 ft. The objectives of this research include the study of bench formation and its causes at upstream slope of Mangla Dam main embankment and to analyze the slope stability considering the present scenario and to suggest the solution to handle the issue.

Waves during storm are responsible for causing significant disturbance to upstream slope. Settlement of stones over a period of time and when water level stays at one elevation for long times also causes bench formation. But the main cause of benches was that a bedding layer was missing under riprap layer from 1170 to 1195 ft.

Rip rap has very small or no fines, while washed gravel has significant amount of fines so under draw down condition benching phenomenon occurred due to removal of fine particles.

SLOPE/W, a slope stability model, was used for slope stability analysis in present study. SLOPE/W is a software to compute the factor of safety of earth and rock slopes. The SLOPE/W makes it possible to easily analyze both simple and complex slope stability problems using a variety of methods to calculate factor of safety.

For the analysis of slope stability, SLOPE/W was used for normal drawdown condition, rapid drawdown condition and without pore water pressure conditions. In each condition five trial benches were drawn in SLOPE/W and minimum factor of safety was computed and trend was observed.

SLOPE/W provides several options for the analysis of slope stability. In order to select the most suitable method, stability analysis was performed for three cross sections of Mangla Dam main embankment at chainage 67+00, 86+00 and 104+00 to represent whole dam in the model SLOPE/W.

Under no pore water pressure condition and without benching, analysis provides the factor of safety 1.846 at 67+00 and under benching condition calculated FOS was 1.459. Under normal drawdown without benching condition, slope stability analysis provides the factor of safety 1.524 at 67+00 and under benching condition calculated FOS was 1.343. Under rapid drawdown without benching condition slope stability analysis provides the factor of safety 1.391 at 67+00 and under benching condition calculated FOS was 1.133.

Under no pore water pressure condition and without benching, slope stability analysis provides the factor of safety 1.838 at 86+00 and under benching condition

calculated FOS was 1.545. Under normal drawdown without benching condition, slope stability analysis provides the factor of safety 1.549 at 86+00 and under benching condition calculated FOS was 1.321. Under rapid drawdown without benching condition, slope stability analysis provides the factor of safety 1.366 at 86+00 and under benching condition calculated FOS was as 1.162.

Under no pore water pressure condition and without benching, slope stability analysis provides the factor of safety 1.840 at 104+00 and under benching condition calculated FOS was 1.464. Under normal drawdown without benching condition, slope stability analysis provides the factor of safety 1.532 at 104+00 and under benching condition calculated FOS was 1.335. Under rapid drawdown without benching condition, slope stability analysis provides the factor of safety 1.372 at 104+00 and under benching condition calculated FOS was 1.140.

Although a decrease in F.O.S with benching phenomenon was observed but still all the values are within safe limits but factor of safety has reduced for all the selected cross sections under bench formation indicate that the replenishment of rip rap is required. For replenishment works performance evaluation of various types of upstream protection layers and their comparative merits and demerits should be evaluated.