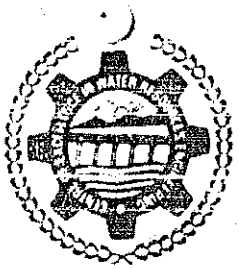
THESIS

STUDY OF CONCRETE ARCH DAM FOR ZARWAM RESERVOIR ON KURRAM RIVER



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ABSTRACT

Zarwam weir is being planned about 8 Km downstream of the Kurram Tangi Dam as a diversion weir for Powerhouse No. 3. This is a low head weir (height 75 ft) to raise the water level for power generation. A tunnel 3400 ft long and 16 ft dia will convey the water to the powerhouse. Zarwam weir is presently being designed as a concrete gravity dam. Arch dam design is new experience in Pakistan. At suitable sites, arch dams can be preferred because of thinner sections, lesser material cost, lesser uplift forces and efficient transfer of forces as compared to the concrete gravity dams. A good quantity of concrete can be saved by utilizing the complete strength of the materials used for dam construction instead of just using the weight of the dam material. Due to the economic advantage of arch dam, it should be tried at a small scale first, as at Zarwam, to gather technical experience. If significant advantages are there than more detailed investigations and design can be taken up.

This study is aimed to plan a suitable layout of the arch dam for the Zarwam reservoir and perform static force analysis of dam section for selected layout and than compare the material quantities for concrete gravity and concrete arch dam.

The methodology in this study primarily comprises of the process adopted for arch dam layout using USACE guidelines. The selected layout has total arc length of 1450 ft at the crest and 1210 ft at the base of the dam. The total chord length of the dam is 1226 ft at the crest and 1060 ft at the base of the dam. Radius of dam at crest is 729'-5" on downstream and 745' on upstream face with average central angles of 114°. Radius of dam at base is 667'-6" on downstream and 711'-6" at upstream face with average central angles of 100°. Static force analysis was performed for the trial sections to reach the finalized layout. Computer softwares like AutoCAD and SAP 2000 are used in the study. A single-center, constant-thickness (lengthwise), arch dam was adopted for this study. A finite element model was prepared in SAP 2000 by using the general layout drawings of the arch dam; it includes the defining of nodal coordinates of shell elements by using the radius of central arcs and general layout drawings, and assigning the materials properties and loads under various loading combinations to the finite element model. As there are no well defined rules for the selection of the mesh size, a number of trials were made for the selection of mesh size. The basic mesh of 10 x 6 was progressively sub divided into smaller sized mesh in every trial. Finally the mesh size in which each element of the basic

mesh was divided into 16 elements was selected because further refinement was not giving much improvement in results.

Five trials were made for the arch dam in this study by varying the cross sectional area. The cross sectional areas from Trial 01 to Trial 05 were 2975 ft^2, 2675 ft^2, 2365 ft^2, 2090 ft^2, 1796 ft^2 respectively. The trials resulted compressive stresses of 52.5, 84.0, 91.0, 112.0 and 140.0 Kip/ft^2 for Trial 01 to Trial 05 respectively and maximum tensile stresses of 7.5, 12.0, 13.0, 16.0 and 20.0 Kip/ft^2 for Trial 01 to Trial 05 respectively.

Trial 05 with maximum compressive and tensile stresses being within the permissible limits of 144 kip/ft^2 (compressive) and 57.6 kip/ft^2 (tensile) was selected as the final cross section.

Maximum tensile stress takes place at the mid length of upstream side near the base. Maximum compressive stress occurs at the mid length of downstream side near middle of the dam height. The volume of concrete for the dam body was calculated to be 2,423,250 ft^3 which is 59 % lesser than the quantity for the concrete gravity dam. Similar saving is expected for steel.

The perpendicular force on left and right abutments is 821.19 kips per linear foot near the top and 311.31 kips per linear foot near the base. The perpendicular force on the foundation is 832.17 kips per linear foot near the abutments and 1125.90 kips linear foot at the mid span.

The smallest possible mesh size must be selected for the analysis in SAP 2000 as a coarser mesh will not give uniform results. The accuracy of force analysis was found to be dependent on model mesh size.

The study shows that arch dam is technically workable at Zarwam site. Further studies are required to be carried out for the site at Zarwam to get more information about the geology of the site and firm up the design. Based on the data available, it is recommended that an arch dam be constructed at Zarwam to get learning and experience in this field of dam design.