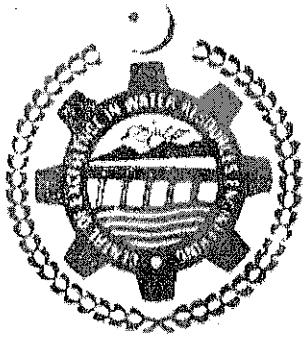
THESIS

OPTIMIZATION OF SPILLWAY CAPACITY AND DAM HEIGHT



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ABSTRACT

Dams are the man made barriers constructed across the flow of river or a stream to store or divert water for different purposes. The ponded water in reservoir can be used for irrigation, water supply, hydropower or recreational purposes. Amongst the different types of dams, embankment dams are more common and contribute about 82% of the total dams in the world. Components of a dam include the dam embankment, spillway, outlet, reservoir, low level tunnels, cofferdams, protection works and monitoring devices.

Spillway is provided to pass the design flood safely without any danger to the dam. The water depth above the normal conservation level of a dam required to pass the design flood is called flood surcharge. Freeboard of a dam, which is the vertical distance between the normal conservation level of a reservoir and the dam crest, is provided to accommodate the flood surcharge storage, wave height and wave run up. Increasing the width of spillway can reduce the depth of flood surcharge and ultimately dam height and embankment cost. At the same time, increase in the width of spillway increases the spillway cost. Therefore it becomes desirable to select such spillway size and dam height for which the total cost of both the components and thus the dam project yield minimum cost.

Kurram Tangi Dam is a multipurpose project proposed on Kurram river just on the boundary of North Waziristan Agency and F.R. Bannu about 9 miles upstream of Kurram Ghari head works and 19 miles north of Bannu city. The proposed dam is a concrete faced rockfill dam with 310 ft high from river bed and having a gross capacity of 0.92 MAF. The length of dam crest is 931 ft. Normal

conservation level of dam is 2100 ft with 15 ft freeboard for flood surcharge and wave action. The spillway is ogee shaped gated control with four bays having a total length of 200 ft. Design flood for spillway is 1,35,000 cusecs whereas the PMF inflow peak is 1,80,000 cusecs. Project cost is estimated as 552.49, 1415.75 and 2137.44 M Rs for embankment, spillway and resettlement respectively.

This study was conducted to optimize cost of Kurram Tangi Dam. The objectives of study included selection of different sizes spillway, preparation of spillway rating curves for selected sizes of spillway, determination of flood surcharge by routing PMF through the selected spillways, determination of required dam height for different surcharge heights, determination of dam and spillway quantities and costs for alternate combination of dam heights and spillway widths, determination of combined dam and spillway cost and selection of optimum dam height and spillway width.

Relevant data was collected including design flood, reservoir area-capacity-elevation curves, dam and spillway design parameters, quantities and costs of different items and the relevant drawings. Spillway rating curves were prepared for spillway widths of 70, 100, 140, 160, 180, 200, 220, 240, 260 and 300 ft keeping the proposed gate opening policy. Inflow hydrograph was routed using the rating curves and HEC-HMS model for different sizes of spillway and corresponding flood surcharge levels were calculated. Dam freeboard was added to the surcharge level to find out the required dam crest levels. The dam of height 327.7, 319.7, 314.2, 312.4, 310.8, 309.6, 308.5, 307.9, 307.5 and 307.3 ft are required for the spillway widths of 70, 100, 140, 160, 180, 200, 220, 240, 260 and 300 ft respectively.

Quantification of dam was done by drawing cross sections of dam for different heights in AutoCAD. The quantities of different sizes spillways were calculated by partitioning the horizontal and vertical components of structure and applying percentage variations on both dimensions with respect to base size dimensions. Item rates selected from the PC-1 of KTD were used to determine the cost of dam and spillway for different alternatives. Total cost of dam and spillway for all the options were added up to find the cumulative cost. The cost of dam, spillway and combined cost were plotted against the dam height and alternative corresponding to lowest total cost was selected to determine the optimum spillway size and dam height.

Embankment cost was 665, 612, 581, 567, 557, 552, 544, 540 538 and 533 M Rs for dam height of 327.7, 319.7, 314.2, 312.4, 310.8, 309.6, 308.5, 307.9, 307.5 and 307.3 ft respectively. Spillway cost was 629, 907, 1153, 1274, 1395, 1516, 1639, 1762, 1878 and 2120 M Rs for spillway widths of 70, 100, 140, 160, 180, 200, 220, 240, 260 and 300 ft respectively. Similarly combined cost was 3737, 3621, 3641, 3662, 3691, 3732, 3829, 3940, 4047 and 4282 M Rs corresponding to spillway widths of 70, 100, 140, 160, 180, 200, 220, 240, 260 and 300 ft. The cost of dam increases with the increase in the dam height but on the other side the cost of spillway decreases simultaneously. The total cost decreases asymptotically from 4282 M Rs for spillway width of 300 ft (corresponding to dam height of 306.9 ft) to 3621 M Rs for spillway width of 100 ft (corresponding to dam height of 320.1 ft). The trend of total cost line indicates the lowest cost for dam height between 2122 ft (width of spillway = 125 ft) to 2124 ft (width of spillway = 112 ft) and thus gives an optimum range of spillway and dam height. The lower optimum dam height i.e. 317 ft against spillway width of 125 ft provides the optimum combination with less resettlement problems and was

thus finally selected. Optimum size of spillway (125 ft) and dam height (317 ft) differs from the designed parameters of spillway width 200 ft and dam height 310 ft. The saving in total cost is about 111 M Rs, which is 3% of the total cost.

As the study was research oriented, therefore some of the factors were excluded or simplified for analysis purposes. The spillway gate opening policy was kept same for all sizes of spillway. Proportionate method has been used to calculate the dam quantities. No analysis of dam stability or seepage has been considered for raised dam. The effect of additional ponding on the topography and geo-technical features were also ignored. Spillway quantities were based on the variations in horizontal and vertical components proportionally without redesigning the structural components for each case. However the effect of ponding on the resettlement has been duly considered and weighted accordingly.