OVERFLOW EMBANKMENT DAMS

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ABSTRACT

Dams out of earth and rock could not allow construction discharges over partly built structures. During the construction period, special arrangement has to be made for passing of construction discharge, incurring heavy expenditure. Precast concrete slabs could be placed on partly built earth or rockfill dam to discharge floods during construction. Same slabs could be utilised subsequently for the next stage for floods. Practical guidelines are furnished for design purposes.

1. Introduction

The tendency to minimise the cost of a project makes everyone conscious of using available local materials in the close proximity. From this fact it is evident that most of the dams of the world are constructed out of earth, rock or a combination of both.

One of the significant disadvantages of a rockfill or an earth dam is the inability to allow water to flow over it. This makes designers to provide a special structure to allow discharges.

A very common type of discharge structure allowing the overflow of water is a concrete overflow spillway. In majority of cases, the cost of the spillway out of concrete exceeds the cost of the main structure.

Due to the excessive cost of the spillway, a new approach is developed to curtail costs of the overflow structure by locating the discharge structure on the dam out of earth or rock.

In deciding the type of structure and the location of it, the hydrology of rivers and other special features should be thoroughly considered.

2. New Structure Developed in U.S.S.R.

High cost of diversion works during construction period, particularly on large rivers with high seasonal variations in discharges, provision of expensive diversion tunnels for short periods, high cofferdams, provision of impervious element in the cofferdam etc. have compelled the Soviet engineers to resort to a design which could overcome the above mentioned constraints.

As a preliminary step to provide an answer to problems, the passage of floods is allowed over low-head partially or fully constructed embankment structures. To maintain stability and to protect the dam faces against erosion, such materials as riprap, wire mesh, anchored beams, concrete slabs, synthetic materials are utilised.

Research made by Pravdivietz at the Moscow Civil Engineering Institute revealed that substantial economic advantages could be gained by using precast reinforced concrete wedge-shaped slabs (see Fig. 1) with drainage holes as protective lining over earth or rockfill dams to allow the passage of flood waters.

3. Main Features of the Structure

(a) The intake section of the structure comprises of two parts, a trapezoidal approach channel in the embankment and a smoothly crested concrete weir elevated over the approach channel bed (Fig. 1).

The approach channel starting from upstream face of dam to spillway weir should be lined with concrete pre-cast slabs or covered with rip-rap. There is a filter zone of suitable gradation under the rip-rap.

The weir consists of an inclined upstream face and a slightly curved pierless crest to maintain high coefficient of discharge. Construction joints are provided in the weir to withstand the uniform and differential settlement of embankment. At the lower end of the weir, a cantilevered projection protects the adjoining row of the slab on the spillway chute against the impact of water jet (Fig. 1). In the case of a weir of a permanent flood control structure with piers and abutments the construction joints run through the piers.

(b) The chute of spillway is constructed out of precast concrete wedge-shaped slabs to a multistepped profile (Fig. 1). The gradient of the spillway chute depends on unit discharge, slab

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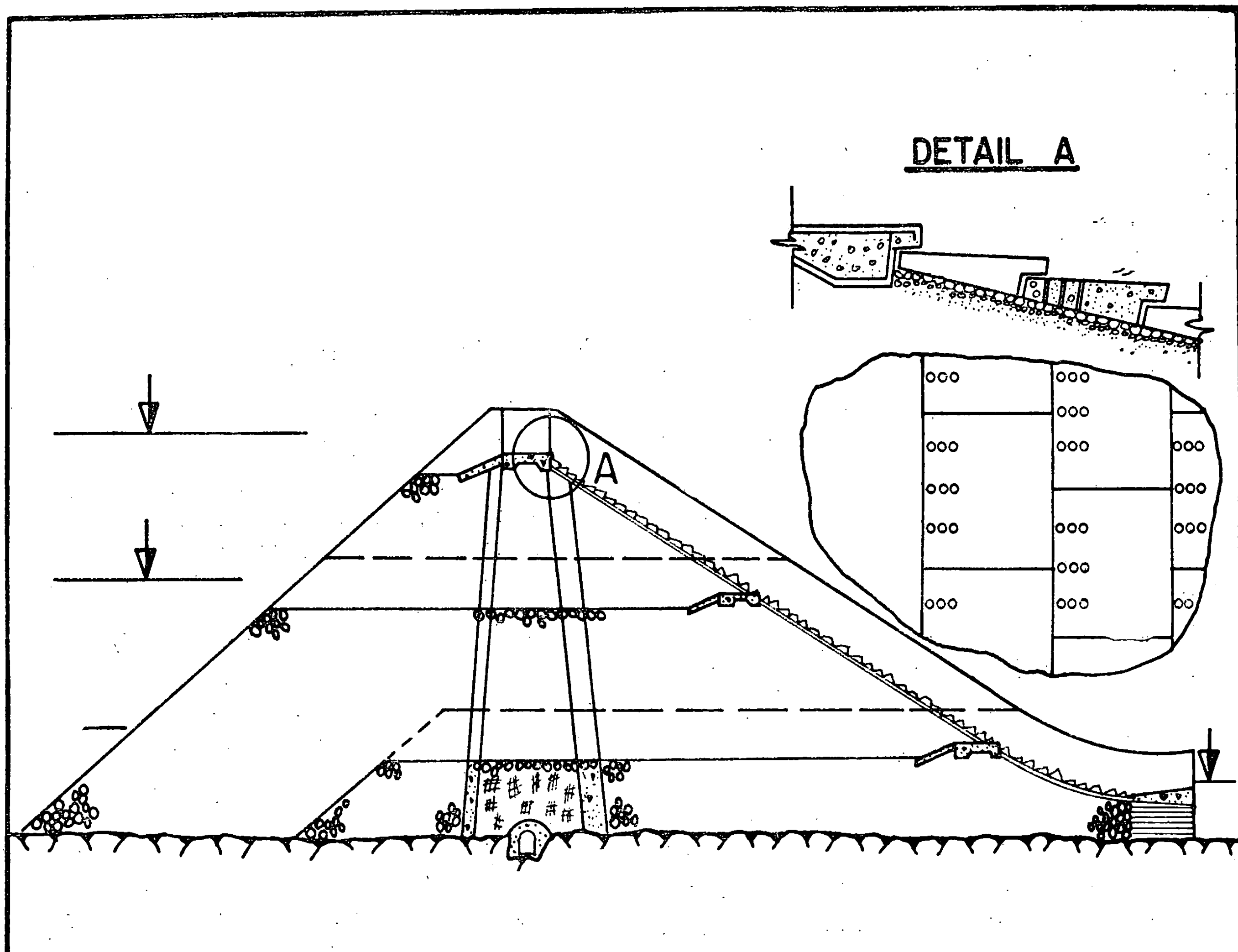

FIG. I OVERFLOW EMBANKMENT DAM PROFILE

dimensions and shear resistance of the underlying fill material. The flow in the spillway chute due to its multi-stepped profile quickly acquires a uniform regime at constant mean velocity and depth. The slope of the spillway chute sides does not exceed 0.3.

The stability of spillway chute (slabs) has the influence of the underlying drainage (filter), draining holes, their dimensions and spacing.

(c) Downstream end of the chute has the stepped toe, which protects the embankment dam from erosion and provides the surface type conjunction of the jet and the tailwater. The non-submerged surface hydraulic jump is proven to be the best regime for the structure.

(d) For high dams, location of the spillway at different levels during the construction period enables the construction floods to be discharged over the partly constructed dam.

As shown in Fig. 1 earth works is carried out keeping in mind the floods to be passed over it. The spillway is located temporarily on the partly built earth bund with the permanent portion of the spillway chute. The work of permanent chute is continued from lower end towards the crest and for the next stage of floods crest of spillway located on the earth works. This process is to be continued till the spillway is located at the final elevation.

4. Design of the Spillway

(a) Determination of the measurements of the spill, taking into consideration the head of water, coefficient of discharge, influence of piers and other factors could be *worked out* by using formulae in hydraulics.

Special emphasis should be paid to design, if the spillway crest to be utilised as a causeway for transport when there is no water flowing over it.

(b) Gradient of chute mostly depends on the bearing friction characteristics of the soil underlying. On clay and sandy-clay slope could be 0.12-0.15; sand and coarse sand within 0.15–0.2; gravel and crushed rock up to 0.2-0.3.

The plan dimensions of the slabs are in a definite relationship with their average thickness. The length L is (4-6) t and the breath equals to (0.7-1.0) $L^{a}{}_{s}$ where ta is the average thickness of slab.

The drainage (filter) under the slabs prevents pipings at the interfaces of the layers and provides free seepage under the protective facing. The usual filter-base grain size relationship applied to the material of the drainage is D_{15}/d_{85} - 4-5. Depending on the embankment material, drainage could be placed in two or three layers; their thickness being (3-4) d_{85} or more but not less than 0.2 m.

The drainage holes in the slabs are round shaped 4-5 cm in diameter, but not larger than the upper-most grain size of the filter material. The rows of holes are spaced 4-5 diameter in longitudinal and 5-6 dia. in lateral directions.

(c) It is of utmost importance to create such a condition at the downstream end of chute of spillway for the safe survival of dam from erosion and to have an economic apron. The non-submerged surface hydraulic jump being the best regime, for creation of it, the following conditions should be adhered to. It exists in the working interval of discharges and tailwater depths provided the top reinforced concrete slab of the toe is not less than 2-2.5 jet depths (in estimated peak flood) and its upper face is inclined upwards upto 6—8°. The tailwater depth and step height providing the non-submerged surface jump are in the following relationship

$$t - 0.93\ (a + 1.7\ h_c)$$

where t — tailwater depth; a-step height;

hc — critical depth

(d) In case the downstream end consists of a foundation out of erodible material, as a rule an apron is provided and the flow is directed to the apron. To assure safety of the structure, the depth of erosion has to be determined corresponding to flow conditions. Maximum erosion depth h could be determined from the expression given by Studenichnikov.