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Length of the Drain Blanket Interns in a Homogeneous Earth Dam

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Abstract: To satisfy the unceasingly increasing water demand and to palliate the scarcity of the easily mobilizable resources, the construction of dams was set as solution that should be taken into consideration to give rise to an impressive number of dams constructed all over the world. Among the different type of constructed dams, the earth dams are the most widespread and the technique of their construction has greatly progressed in time without elucidating all the phenomena and hence developing methods which agree with the dual level technical and economical. Besides the empirical methods are improved but remain with no absolute guarantee against destructive accidents. The infiltrations represent the main causes of damages pointed out on earth dams throughout the world for which increased attention is given to means to battle with their effects and it is always provided a water drainage system in the earth dams. However a drain cannot be effective unless it is well dimensioned and carefully laid down in the fill embankment. This is an impossible task to realize in so far as we make use of doubtful and succinct recommendation to fix the drain length. A graph is given in this study and allows reading directly the length of the internal drain blanket in a homogeneous earth dam. This was obtained after having carried out a simulation of a great number of earth dams by varying the total height, the embankment slopes and the material characteristics. For each dam, the drain length is changed within the acceptable limits of the hydraulic stability and the landslide stability of the down stream side embankment is calculated.

Key words: Earth dam, Drain blanket, infiltrations, stability, piping, phreatic line

INTRODUCTION

Usually, the length of the internal drain blanket in a homogeneous earth dam is taken in the range (1/4, 1/3) (Georges, 1978) of the surface of the dam. The present study is devoted to the exact determination of this length. To this end, in a first instance, we have undertaken an investigation to identify the elements which have direct or indirect links with the drain blanket such as the total height of the dam, the upstream and the downstream slopes of the embankment, the types of the materials and the extreme upstream and downstream positions of the internal drain blanket.

The second step is concerned with the verification of the mechanical stability of the earth dam.

A computer program has been developed which can be used for dams whose height varies from 1.0 to 400 m. For each dam we vary the slope from 2 to 7, with a variable position of the drain blanket within a range limited by two extreme upstream and downstream positions.

The computational results for all the dams are given in tables and to facilitate their use, they are presented in a graphical way purpose of the internal drain blanket in a homogeneous earth dam.

THE ROLE OF AN INTERNAL DRAIN BLANKET IN A HOMOGENEOUS EARTH DAM

The role of an internal drain blanket in a homogeneous earth dam is very important for the working of the structure and also for its mechanical and hydraulic stability (Bardet, 1997). The drain allows:

- To lower the line of saturation to avoid resurgence on the downstream slope.
- To keep a large part of non saturated backfill which enhances the mechanical stability of the structure by avoiding the diminution of the internal friction angle.
- To minimise the flux looses through the body of the dam.
- To collect and evacuate the seepage water in the dam and its foundation

METHOD OF DETERMINATION ON THE SATURATION LINE

The saturation line has a shape of a parabola as all other current lines, but its theoretical point of intersection with upstream face does not coincide with the practical

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point of intersection. To determine the value of the shift between the two points we can use two methods:

The first one is the parabola method of Kozeny (Costet and Sanglerat, 1981) and (Habib, 1997) where the distance between the two intersection points practical and theoretical is taken as 30% of the horizontal projection of the wet part of the upstream face.

The second one is called the method of changing the upstream embankment in a vertical face keeping the same value of pressure drop for the two cases (Jouravlev, 1979; Gerard, 1997). Thus the distance between the two points, theoretical and practical, is given by the expression:

$$\lambda H_1 = \frac{m_1}{2m_1 + 1} H_1 \qquad (1)$$

With

λH_1 = Distance between the two intersection points

H_1 = Height of the normal level of the reservoir

m_1 = Slope of the upstream embankment

Once we have computed this distance by the two methods for different heights of the dam and different slopes of the upstream embankment and with a reference to exact results obtained with the method of electrical analogy, we have decided to use the method of changing the upstream embankment since it gives results close to the reality.

METHOD OF CALCULATION OF STABILITY

The hydraulic stability: When the water soaks trough a ground, this latter is submitted to actions which result from the presence of a moving or not liquid in its interstices. The study of this problem is facilitated by the possibility of separating the different stresses which the each phase where three forces can act (Daniel, 1984; Anonymous, 1985):

- Gravity force
- Force of the hydrostatic uplift pressure
- Pressure force of the current

The resultant of these three forces gives a final force which acts on the solid phase. The intensity of this force is given by the algebraic sum of the intensities of the three forces represented by the hydraulic gradient (gradH), this latter in increasing can result in the force being null and the solid phase will be subtracted from the action of gravity which is called the boiling phenomenon. If the hydraulic gradient continue to increase the solid grains will uplift and will be entrained by the current which is called the piping phenomenon (Anonymous, 1994).

In the techniques of constructing earth dams it is usual to define a critical hydraulic gradient (Jouravlev, 1979) depending on the materials used beyond which the piping phenomenon is initiated.

For the sequel of the present work we have used the results from the research of Pr Tchougaév (Gerard, 1997) who has fixed the admissible values for the hydraulic gradient for different types of earth fill dams and for each desired height.

Mechanical stability: The essential problem encountered in the construction of backfill with compacted earth is the one linked to their stability against slipping. The mechanism which leads to the fracture of the embankment has been the subject the approaches more or less simple but is sufficient to determine the safety factors which can give indications concerning the stability of the embankments. In this study we have adopted the simplified method of Bishop (Costet and Sanglerat, 1981) which we consider acceptable for earth dams.

The determination of the position of the centre of the critical circle can be done with the method of FEEDEV (Gerard, 1997) This method suggests to place the centre of the considered circle inside a contour limited on one hand by two straight lines, one vertical a line, the other having an angle of 85° with the downstream embankment and both passing through the mid point of the same embankment and on the other hand by two arcs with the same centre situated at the intersection point of the two lines and radii given in terms the total height of the dam.

DIMENSIONS OF THE DAM

To develop the computer program, we have fixed the dimensions of the dam as follow Fig. 1.

Height of the dam H: The total height of the dam varies from 1 to 400 m with a step of computation of 1m

Height of the normal level: By considering a constant height discharge for all the heights of the dam equal to: h = 1.5 m

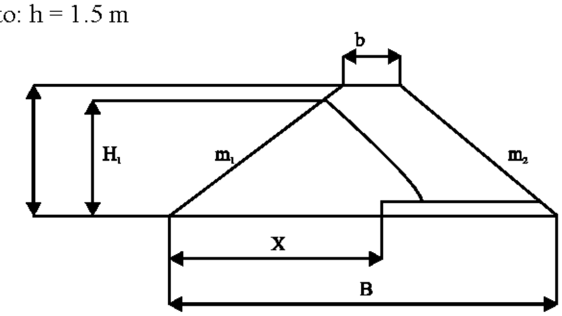

Fig. 1: Earth fill dam with line of saturation

A freeboard R in terms of the height of the waves varying along the height of the dam (H) is given as follows:

H≤100 m	R = 2.50 m
H≥100 m	R = 5.50 m

Which yields the normal height of the dam as:

$$H_1 = H-(h+R) \quad (2)$$

Thickness in crest b: It is taken as varying with the total height of the dam

b = 9.00 m	if	H≤100 m	
b = 14.00 m	if	100< H<200 m	(3)
b = 19.00m	if	H≥200 m	

Slopes of the embankment: By analysing the different techniques relating to the construction of the earth fill dams and particularly the recommendations of Terzaghi (Georges, 1979), we proposed to vary the downstream slope (m_2) in the range (Habib, 1997; Daniel, 1984; Geoge, 1953; Bardet, 1997; Marcel, 1977; Anonymous, 1985).

The value of the upstream slope (m_1) is deduced using the relation:

$$m_1 = m_2+1 \quad (4)$$

Internal drain blanket: The thickness of the drain blanket is taken equal to 2.00 meters for all the dams considered in the computations (Georges, 1978).

The position of the blanket drain will be variable but stays in the interior of the efficient zone delimited by the two following extreme positions:

- Downstream extreme position where the saturation line is tangent to the downstream face.
- Upstream extreme position where the hydraulic slope is allowable (Jouravlev, 1979).

RESULTS AND DISCUSSION

We have obtained results giving the slipping stability coefficient (Gerard, 1997) for each considered dam in terms of the positions of the internal blanket drain.

A study of the results allowed us to retain the case where the stability coefficient is allowable and to facilitate their exploitation, we thought that it will be more judicious to present then in graphical form giving directly the position of the internal drain blanket in terms of the height of the dam and its downstream slope Fig. 2.

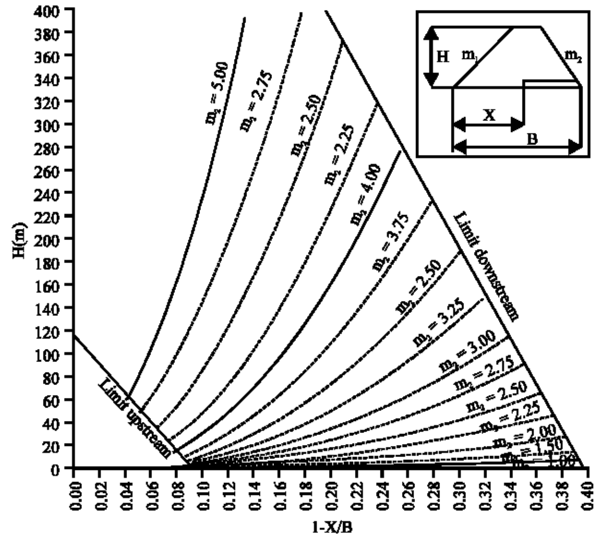

Fig. 2: Length of the internal drain blanket in a homogeneous earth dam

CONCLUSION

The determination of the length of the internal drain blanket by using the graph is of great simplicity, since we have the possibility to fix it exactly and rapidly for each height and slope of the dam.

Hence, we dispose of an efficient tool to fix this length by taking into account all the factors which have direct or indirect influence on the stability of the dam, the total height of the dam giving the hydraulic charge which results in infiltrations through the porous b loc, the choice of the slopes of the embankment which depend on the materials used and the position of the saturation line which delimits the saturated part of the bloc.

We stress that all the heights of the internal drain blanket obtained using the graph are included in the traditionally range used in the practical computations of homogeneous earth dams (1/4, 1/3).

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