Editor's Note. A reduction in the cost of constructing large canals in an earth bed is quite urgent. The partial slope protection (instead of continuous) proposed by the authors as a means of increasing the stability of unlined canals deserves serious attention. The results of the laboratory investigations seem sufficient for proceeding to the construction of full-scale experimental stretches of canals under various engineering-geologic conditions. Such full-scale investigations will serve as the basis for a final judgment of the effectiveness of partial slope protection of large unlined canals and will make it possible to refine the area of use of such protection under various engineering-geologic construction conditions.

INCREASE IN THE STABILITY OF UNLINED CANALS BY MEANS OF PARTIAL SLOPE PROTECTION

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A large number of earth canals without protective coverings are supposed to be constructed in the near future. It is customary to consider that the variant of a canal in an earth channel, i.e., without protection of either the bed or slopes, is the most economical. At the same time an analysis of field observations shows that during operation the cross sections of the majority of canals undergo considerable deformation, especially in readily eroded soils. Large annual expenditures are needed to keep such canals in a working condition, in connection with which the problem of their reliable and trouble-free operation is extremely urgent.

The selection of the channel shape and assignment of the permissible flow velocity in unlined canals depend on the hydraulic regime of the flow for which the stability of the channel should not be disturbed.

It is usually difficult to trace the initial course of deformations under full-scale conditions, and therefore a number of laboratory experiments were set up on erodible models of various cross sections with a discharge range of 15-100 liters/sec.

Three series of experiments were conducted. The experiments were conducted on a channel model composed of Amu Darya sand with an average diameter $d_{av} = 0.2$ mm. The length of the model was 24 m, width 4 m, and height of the sides 1 m.

Fig. 1. Cross section of canal in the 1st experiment. $B/h_{av} = 21.0$. 1) Distribution of the Froude number $F_{rv}$ over the width of the channel; 2) permissible value of the Froude number $F_{r0}$; 3, 4, 5) respectively diagrams of the maximum, average, and bottom flow velocities; 6) isovels; 7) cross section of canal.

Fig. 2. Cross section of canal in experiment 2 (see Fig. 1 for notations).

In the experiments of the first series the flow was allowed to form a dynamically stable channel of the canal and initial ratio \(v/v_0 = 0.8-1.2\) (\(v\) and \(v_0\) are, respectively, the average and noneroding flow velocity). Processing of the results obtained showed that the pressure of large velocity gradients in the zone near the water's edge was one of the main causes of the deformations that occurred, which consisted in an increase in the surface width and decrease in the average depth.

In the experiments of the second series the cross sections of the canals were designed so that in them not only \(v/v_0 < 1\) but also \(F_{r0} > F_{rV}\) (\(F_{r0}\) is the permissible value of the Froude number calculated for the entire flow of \(v_0\) and average depth \(h_{av}\); \(F_{rV}\) is the local value of the Froude number calculated for the average velocity \(u_v\) and depth \(h_v\) of the vertical (observation point).

Figures 1-3 show the final cross sections of the canals in experiments of the second series. The main hydraulic parameters of the experiments are given in Table I.

As we see from Table I, the canal channel in experiment 3 was subjected to the greatest deformations. The cause of the deformation lies in the displacement of the channel line as a result of hydraulic instability of the flow. This is seen clearly from the character of the distribution of the Froude number over the canal width in experiment 3 (Fig. 3). Comparing Figs. 1-3, we see that the stability of the flow is disturbed with an increase in the relative width.

Two experiments of the third series were conducted for a more detailed study of the conditions of formation of a stable canal channel.

The original cross section of the canal in the 4th and 5th experiments had the shape of cosine curves.

Table 2 shows the values of the hydraulic parameters of the third stage.