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The design of open-channel expansions is a problem of common occurence in the execution of Hydraulic and Irrigation structures. The approaches in the past have been broadly empirical in nature and attempts were made to use long lengths of transitions and different shapes of curves for the sides, in an effort to minimise head loss or afflux and cause minimum scour to the bed and sides beyond transitions. As revealed through model studies, the performance of such designs are not satisfactory, besides the fact that they are neither economical in cost of construction nor are they easy to construct. The need, therefore, exits for a thorough experimental investigation to gain insight into the mechanism of energy loss and scour formation in wide-angle expansions and also evolve suitable devices for efficient performance of such expansions.

In the field of aeronautics, much work has been carried out for the design of diffusers and aerofoils, making use of boundary layer theory, and certain effective devices have been developed to control separation and improve performance. However, in the allied field of Irrigation and open-channel Hydraulics, elementary methods of analysis such as one-dimensional technique have been in adoption and little use is made of the techniques of boundary layer flow control which have yielded large rewards in the field of aeronautics. The present investigation which is in continuation of an earlier work of the author for the Master's thesis, was taken up with the following objectives in view, viz.,

(i) to define efficiency of flow expansion in a rational way taking into consideration the flow characteristics in an expanding passage and develop the expression for overall efficiency of an expanding transition,

(ii) to study the phenomenon of boundary layer separation and stalling in open-channel expansions with triangular vanes as controlling devices,

(iii) to evolve optimum geometric proportions for the vanes and their alignment in terms of hydraulic parameters,

(iv) to prepare a set of design curves to illustrate their use in practical designs.

A critical review of the literature pertaining to the subject has been prepared.

Analytical considerations involved in the problem are discussed and the following criteria for the design of efficient subcritical flow expansions have been developed. They are:

(i) Hydraulic efficiency indicating the total head loss due to expansion and expressed as ratio of actual recovery of head to the one corresponding to ideal inviscid flow,

(ii) Exit bed shear distributions representing the scour effect. The standard deviation of the actual bed shear distributions from the normal one for uniform flow is chosen as a parameter defining the scour criterion,

(iii) Separation and stall characteristics representing the smoothness of flow in the tail channel.

Experimental investigations have been carried out on models of a wide angle straight expansion of 3:1 side-splay (which corresponds to a total angle of expansion of about 37°) for different discharges and depths. More than 600 experimental runs were taken in a glass sided flume. Hydraulic efficiency was calculated by accurately measuring the water surface profiles. Velocity distributions were recorded by Prandtl tube and the standard deviations of the exit bed shear distributions were computed. Zones of flow separation and development of stall for various orientations of vanes were observed visually, recorded and plotted. Studies have been conducted also with mobile beds to observe the effect of the vanes on the magnitude and pattern of scour.

The results were analysed and presented graphically with a view to evolve the optimum proportions for the size and orientations of the vanes, and to find the head loss, scour, and stalling pattern for the expansion provided with vanes. The performances were compared with those of plain expansion without vanes for any given condition of flow. Typical design calculations are furnished to illustrate the utility of the several curves prepared and their application to practical designs.

Summary of the studies and salient conclusions are given and the scope for further work has been stated.

A list of references on the subject is prepared. Certain observations, calculations and results forming the background data are presented in the form of appendixes.