CHAPTER I

INTRODUCTION

In the design of head-retaining structures, such as dams, barrages, river weirs, tank weirs, canal falls, gully plugs, and similar structures, the problem of energy dissipation and control of scour downstream is commonly encountered. One of the standard techniques for the solution of this problem has been to construct a hydraulic scale model according to Froude law and use a homogeneous granular material of a suitable size to represent the erodible bed of the river. The size of the material is so chosen that it will not be too fine as to be bodily transported but will be able to produce a scour profile which stabilises after some time. The scour profile then serves for all practical purposes as an index to compare the relative efficacy of performance of different energy dissipation devices to be experimented upon.

Generally, sectional models in glass sided flumes are employed to scales not smaller than about 1/60, although the solutions evolved are also tested in comprehensive or three-dimensional models constructed to smaller scales of about 1/100. Attempts were also made in the past to simulate the scour depth to scale in the model in an effort to predict the prototype scour but not with much success. The scour profiles observed are found to be influenced, among other factors, by the size of the granular material used in the model as well as the scale of the model. Therefore, it is necessary to study and gain a deep insight into the mechanism of energy dissipation and scour.

The kinetic energy due to high velocity of flow at the exit of a structure is manifesting itself in the moving mass of water with varying depths and velocities, characterised by eddying zones and turbulence, while a part of the energy alone is converted into heat and lost permanently. Thus, the residual kinetic energy of the flow and the undecayed part of induced turbulence are still left over to be taken care of. Of what magnitudes and in what proportion these two energies sustain themselves and to what extent they are capable of causing any damage to the downstream channel can not be predicted as yet by means of the available hydraulic theories based on the principles of conservation of mass, momentum, and energy applied to the mean flow conditions only.

A rational assumption in this context may be that the net effect of all forms of undecayed or undissipated energy is reflected in overcoming the frictional resistance of the boundary to the flow accompanied by such phenomena as erosion, sediment deposition and sediment transport. The specific purpose of all energy dissipators is the inhibition of erosional effects throughout the boundaries of the receiving channel. The "regime" concept embodying the maximum permissible mean velocity as an index of the resisting capacity of the channel to erosion is not adequate to explain the local scours caused due to variation in the velocity distribution pattern characteristic of open channel flow. Besides, the flow is further complicated by the existance of secondary currents which are induced by such factors as the shape of the channel, the existance of a free surface and the vorticity. On the other hand, the "tractive force" concept takes into account the effect of secondary currents as well as turbulence and lends itself for the examination of the distribution of shear stresses on the bottom and side slopes of the receiving channel, and as such it may be used as a satisfactory criterion for predicting erosion hazards.

For the measurement of drag or boundary shear at various locations, the Preston tube technique[1] developed originally for air-craft structures has been utilized by Ippen _et al_[2] in trapezoidal open channel bends. By this technique, the boundary shear is computed from a single observation at any location with the Preston tube and it is proved to be valid analytically by Hsu[3] on the assumption that the $\frac{1}{7}$-th power-law for velocity distribution applies. However, the present studies by the writer have revealed that the above law does not apply to the flows in the rear of hydraulic structures discharging into narrow channel sections. Hence, the primary objective of these investigations is to develop a technique for the determination of the exact distribution of drag along the boundaries of narrow channels below hydraulic structures.

From the statistical fits to the observed velocity profiles non-dimensionalised in terms of shear velocities computed from Preston tube data, it is found that different power-laws are fitting the velocity profiles at different positions in a narrow test channel below a typical hydraulic structure namely the vortex energy dissipator. Corresponding to such a modified power-law for any velocity profile in question, a non-dimensional equation in general terms similar to that of Hsu is deduced. This enables the determination of drag accurately at any point on the bed consistent with the velocity profile at that point.

The second objective of the investigations is to evolve a technique by which the drag distribution at a desired section in the narrow channel below a hydraulic structure may be determined. By using the average values of different exponents and coefficients of the power-laws fitting the observed velocity profiles in such a section, a boundary shear equation applicable for the entire cross-section is derived. Besides, with certain rational assumptions, the same technique is found useful for the study of drag patterns over the entire bed in the same narrow channel below two different types of hydraulic structures namely the chute spillway and the vortex energy dissipator.

The third objective of the investigations is to examine the correlation, if any, between the drag and scour patterns downstream of a hydraulic structure on a narrow channel bed. Two types of model studies for each of the above mentioned structures are carried out - one with a rigid bed and the other with an erodible bed beyond the apron of the hydraulic structure. The drag distributions are determined by the above mentioned technique at different sections downstream of the rigid bed models. Scour patterns are developed in the erodible bed models and measured by means of the available standard techniques. There is no direct correlation between the drag and scour patterns, inasmuch as the scour patterns in model studies would not simulate to scale the prototype conditions. On the other hand, the drag is found to represent the primary causative force of scour, the knowledge of which is vital in the assessment of the efficacy of energy dissipators. The drag varies with time as the scour pit develops. The final stable scour, if attained after some time, has to satisfy the condition of critical drag for the bed material at all points on the surface of the scour pit.

The investigation is therefore experimental in nature involving basic research on the phenomena of drag and scour.