Design of Stilling Basin with Stepped End Sill

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Abstract

Stilling basins are frequently used to dissipate excess flow energy at downstream of hydraulic structures such as spillways which may otherwise cause excess scouring in the river bed and hence may lead to failure of the hydraulic structure itself. Thus, design of stilling basin is an important technical and economical activity. In the design of stilling basin, length and geometry is very important as it affects the formation of hydraulic jump, and hence the energy dissipation. In this study, the impact of end sill in the stilling basin is studied through the model study of Siahbisheh Dam spillway in Iran. A stepped spillway with 1.5 m width and a stilling basin at the downstream of the stepped chute were constructed to evaluate stilling basin performance. Four stepped end sills were tested at three different locations of 2.3, 2.4, and 2.8 m from the beginning of the stilling basin. Various flow characteristics were studied for three different discharges. Five different cross sections were considered in the stilling basin to investigate forced hydraulic jump properties. Hydraulic characteristics of forced hydraulic jump by various aspects of stepped end sill have been compared with classical hydraulic jump characteristics. Further, the best design combination has been suggested on the basis of hydraulic characteristics of the jump under variable conditions.

Key Words: Stilling Basin, Energy Dissipation, Hydraulic Jump, Length of Jump

1. Introduction

Energy of water over the spillways must be dissipated to prevent scouring downstream riverbed which can cause to failure of structure. Dissipation of energy at the base of traditional open chute spillways can be accomplished by several means. The two most common approaches are to use a flip bucket to force the flow away from the structure and allow energy dissipation in a plunge pool downstream the dam and critical structures, or some type of structure at the end of the spillway chute to dissipate the remaining energy (Frizell, 2009). Stilling basins are the most common types of energy dissipaters which force a hydraulic jump, thus transforming the incoming supercritical flow to subcritical flow exiting the basin. It is a structure in which a hydraulic jump is generated and has been designed economically in terms of length, tailwater level and scour. The selection of a stilling basin depends on approach flow conditions, tail water characteristics, potential of scouring, and personal preferences. A number of standard basins are available that have been tested extensively by Peterka (1958), USBR and other researchers (Frizell, 2009).

The basins are usually provided with special appurtenances including chute blocks, baffles piers and sills. Chute blocks are used to form a serrated device at the entrance to the stilling basin to furrow the incoming jet and lift a portion of it from the floor producing a shorter length of jump than would be possible without them. Baffle piers are blocks placed in the intermediate position across the basin floor to dissipate energy mostly by impact action. They are useful in small structures with low incoming velocities. They are unsuitable where high velocities make cavitation possible. The sill is usually provided at the end of stilling basin. Its function is to reduce further the length of the jump and to control scour. The sill has additional function of diffusing the residual portion of high velocity jet that may reach the end of the basin. These components typically allow the shortening of basin and can increase the factor of safety for the possibility of sweep out.

Earlier stilling basin research has mostly featured smooth chutes. Boes and Hager (2003) suggested that, as long as the mean velocity and unaerated flow depths are used in calculation of the Froude number, the traditional design criteria should apply. Cardoso, et.al. (2007) presented data for a standard type III basin without chute blocks for steep (0.75H:1V) smooth and stepped chutes and concluded that the dimensionless