EXPERIMENTS ON NEW STILLING BASINS FOR PIPE OUTLETS

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***Abstract*— *This paper presents an experimental study on new stilling basins for non circular pipe outlet The new developed models were tested in a rectangular shaped pipe outlet of size 10.8cm x 6.3 cm with three inflow Froude numbers Fr = 1.85, 2.85 and 3.85 in comparison to USBR VI stilling basin model recommended for the pipe outlets. The new stilling basin models were developed by changing the shapes of the end sills of same height, while keeping the other configuration of stilling basin geometry same. To compare the performance of stilling basin models in different Froude numbers, the maximum scour depth and its location from end sill were measured for each model. The study indicates that due to changing the end sill geometry, scour pattern and hence the performance of stilling basin affected significantly.*

Keywords- End sill, Froude number, Scour pattern, Stilling Basin.

I INTRODUCTION

Stilling basins are used for dissipating the excessive kinetic energy of flowing water downstream of hydraulic structures like overflow spillways, sluices, pipe outlets, etc. to prevent scouring of the riverbed and failure of the structure (Alikhani et al. 2010). Various types of recommended stilling basin designs used for pipe outlets are, by Bradley and Peterka (1957), Fiala and Albertson (1961), Keim (1962), Vollmer & Khader (1971), Garde et al. (1986), Verma & Goel (2000 & 2003), Goel (2008) and Tiwari et al. (2011), etc. A stilling basin for a pipe outlet consists of appurtenances like splitter block, impact wall, intermediate sill and an end sill etc. The vertical end sill is an element in the stilling basin, which has a great contribution in reduction of energy of flowing water and assists to improve the flow pattern downstream of the channel. The sill height, configuration and position have great impact on the formation and control of hydraulic jump and ultimately leading to the dissipation of energy of flowing water. Several shapes of the end sill have been used by many investigators. In the USBRstilling basin type VI model, a sloping end sill is used as proposed by Bradley & Peterka (1957), while Garde et al. (1986) and Verma & Goel (2003) have recommended a semi circular shaped end sill as well.In this research article, experimental investigation was carried out to study the geometry of end sill in order to develop the new models of the stilling basin for rectangular pipe outlet in comparison to USBR VI stilling basin model. Different geometry of end sill studied is shown in Fig.1.

II MATERIALS AND METHODS

(a) Flume & Basin

Experimental work was carried out in a recirculating flume of dimensions 0.95 m wide, 1 m deep and 25 m long in the hydraulics laboratory of Civil Engineering Department of MANIT Bhopal. According to the stilling basin design considerations as suggested by Bradley & Peterka (1957), the width of flume was reduced to 58.8 cm by constructing a brick wall along the length as per the requirement of width of flume. Rectangular pipe of 10.8 cm x 6.3 cm was used to represent the outlet pipe. This pipe was connected with feeding pipe of diameter of 10.26 cm connected with centrifugal pump. For measurement of discharge, venturimeter was fitted in to the feeding pipe. The exit of outlet pipe was kept above stilling basin by one equivalent diameter (d = 9.3 cm). A wooden floor of size 58.8cm wide and 78.6 cm long was provided, downstream of the exit of the pipe outlet for fixing the appurtenances inside the basin. Three inflow Froude numbers namely Fr = 1.85, 2.85 and 3.85 were used as per discharge consideration in the flume. A manual tail gate was used at the end of the test bed in the flume to control the tail water depth for experimentation.

(b) Bed Materials

To observe the scour, after the end sill of stilling basin, an erodible bed, consisting of coarse sand of specific gravity as 2.76, and passing through IS sieve opening size 2.36 mm. and retained on IS sieve opening size 1.18 mm was used. For all testing same bed material was used to compare the basin performance. The characteristics of bed materials are summarized in Table 1.

Specific gravity (S)	Density ρ_s (kg/m^3)	Uniformity coefficient C_u	Coefficient of curvature C_c	d_{60} (mm)	d_{50}(mm)	d_{30}(mm)	d_{10}(mm)
2.76	1648	1.57	0.93	2.2	1.9	1.7	1.4

Table 1 : Characteristic Of Sand Bed Materials

(c) End Sills

During the experimentation to evolve new stilling basin models rectangular, square, and triangular of varying slope from 1V:0.5H to 1V:2H and trapezoidal end sills were used as shown in Figure 1. Impact wall of dimension 1d x 2.2d was employed to facilitate the dissipation of energy in the basin.

III EXPERIMENTAL PROCEDURE

First of all, the movable sand material was filled up to the height of end sill and leveled then normal depth was maintained over the sand bed by allowing the water from the overhead tank inside the flume by operating the tail gate. Later on, a centrifugal pump of capacity 20 HP was switched on while keeping the control valve closed, fitted into the feeding pipe. The flow into the flume was increased gradually so as to achieve required Froude number with a minimum possible disturbance to the erodible sand bed. The discharge was measured by a calibrated venturimeter installed in the feeding pipe. With the operation of tail gate, the desired steady flow condition with normal depth of flow was maintained, which was computed by Manning's formula corresponding to the inflow Froude number $Fr = V/(gd)^{0.5}$,where V is the average velocity in the pipe, g is the acceleration due to gravity and d is the equivalent diameter of the pipe. As soon as the required amount of water flowing from pipe outlet, reached the erodible bed material, the movement of bed materials started and the geometry of scour hole started changing with time. After one hour test run, the motor was switched off. The value of maximum depth of scour (d_m) and its location from the end sill (d_s) were noted. All the models were tested for constant run time of one hour and with the same erodible material for all Froude numbers. To start the experimentation, a stilling basin model was designed for the inflow Froude number (Fr= 3.85) and fabricated in the flume as per USBR impact type VI design. It includes an impact wall of size 1d x 2.2d having a bottom gap 1d, located at 3d from the exit of pipe outlet and followed by sloping end sill (slope 1V:1H) of height 1d positioned at 8.4 d where d is the equivalent diameter of the pipe outlet. Later on, in order to study the end sill geometry, new stilling basin models were fabricated by changing the shape and the size of end sills (10 Models). During the test runs for all the stilling basin models, the grain size of the material forming the erodible bed and test run time of one hour were kept the same for the purpose of comparison of the model performance. The details of stilling basin models tested have been mentioned in Table 2. Some of the tested models are shown in Figs. 2&3

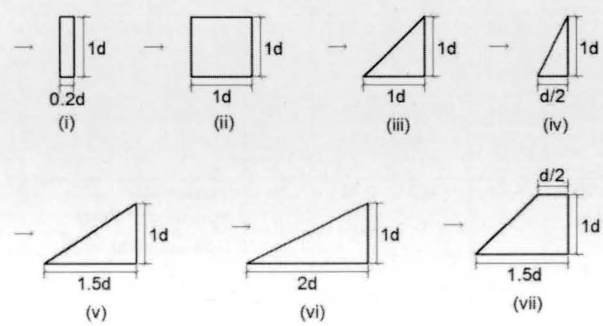

Figure 1 :Different shapes of end sills tested

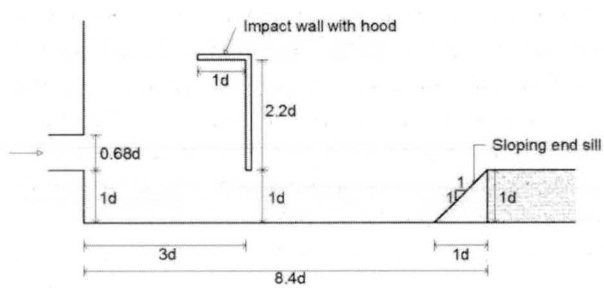

Figure 3 :Stilling Basin model MSM-6 having sloping end sill with impact wall

Model number	Stilling basin length	USBR VI Impact wall			End sill of height 1d
		Size	Location	Bottom gap	
MSM-1	8.4d	-	-	-	Rectangular
MSM-2	8.4d	-	-	-	Square
MSM-3	8.4d	-	-	-	Sloping(1V:1H)
MSM-4	8.4d	1dx2.2d	3d	1d	Rectangular
MSM-5	8.4d	1dx2.2d	3d	1d	Square
MSM-6	8.4d	1dx2.2d	3d	1d	Sloping(1V:1H)
MSM-7	8.4d	1dx2.2d	3d	1d	Sloping (1V:0.5H)
MSM-8	8.4d	1dx2.2d	3d	1d	Sloping(1V:1.5H)
MSM-9	8.4d	1dx2.2d	3d	1d	Sloping(1V:2H)
MSM-10	8.4d	1dx2.2d	3d	1d	Trapezoidal Sloping(1V:1.5H) with top width d/2

Table 2 : Scheme Of Experimentation

IV CONCLUSION

An experimental study was carried out in the laboratory for investing the performance of new stilling basin with end sill for non circular pipe outlet. Based on the experimental results, it is found that the shape of end sill in a basin affects the performance of stilling basin significantly due to change in the flow conditions. During the study it was found that the shape of end sill affects the flow conditions and ultimately scour pattern downstream of the stilling basin. This study also revealed that the sloping vertical end sill (slope 1V:1H) dissipates more energy of flow and found to perform better for all flow conditions as compared to other end sills (showing lower values of d_m) tested for rectangular pipe outlet basin. The variation of scour parameters is due to the variation in flow geometry because of varying the shape of end sill.

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