Design of Stilling Basin Models with Intermediate- Sill

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ABSTRACT

In this research paper performance of new stilling basin models for pipe outlet stilling basin were investigated experimentally by using different shape and size of intermediate sills along with impact wall and end sill .The experimental study was carried out for two Froude numbers namely 3.85 and 1.85 for rectangular pipe outlet of size 10.8 cm. x 6.3 cm. Performance index (PI) has been defined to evaluate the performance of stilling basin models tested using same sand base material and test run time. The scour pattern was measured for each test run. After 36 tests runs, it was found that scour process were reduced for a specific size and shape at a particular location of intermediate sill combined with end sill of particular size and shape. Newly developed model emerges more efficient as compared to other tested stilling basin models

Keywords: Performance index, end sill, stilling basin, pipe outlet, Scour pattern.

I. INTRODUCTION

Stilling basins with sills can be used effectively in dissipating the excessive energy downstream of hydraulic structure like over flow spillway, sluices, pipe outlets etc. Negm(2004) reported that the effect of sill on the flow depends upon the configuration of the sill, its geometry and the flow regime .Various types of recommended stilling basin designs for pipe outlets are by Bradely and Peterka (1957), Fiala and Albertson (1961), Keim (1962), Flammer et al. (1970), Vollmer and Khader (1971), Verma and Goel (200 & 2003) , Goel (2008), Tiwari et al. (2011, 2012 &2013), Tiwari and Gahlot (2012) and Tiwari (2013 & 2013). The present research paper concentrates on the effect of the position , shape & size of the central sill with end sill in stilling basin on scour characteristics downstream of the basin including the maximum depth of scour, the length to the maximum scour from end sill, the flow and scour patterns.

II. MATERIALS AND METHODS

(a) Experimental Arrangement

The experiments were conducted in a recirculating laboratory flume of 0.95 meter wide 1 meter deep and 25 meter long at MANIT Bhopal. The width of flume was reduced to 58.8 cm. by constructing a brick wall along the length for keeping ratio of width of basin to equivalent diameter of rectangular outlet equal to 6.3 as per Garde et al. (1986). A rectangular pipe was used to represent the outlet flow. This pipe was connected with delivery pipe in centrifugal pump. The exit of pipe was kept above stilling basin by one equivalent diameter (1d = 9.3cm). A wooden floor was provided downstream of the outlet for fixing the appurtenances in the basin.

Scheme of Experimentation

Table 1

S.No.	Model Name	Impact Wall with hood: Size	Bottom gap with basin floor	Location from outlet exit	Intermediate sill: Shape	Height	Width	Location from outlet exit
1	MSM-11	1d×2.2d	1d	3d	Triangular with vertical face U/S	2.5d	1d	4d
2	MSM-12	1d×2.2d	1d	3d	Triangular with vertical face U/S	2d	1d	4d
3	MSM-13	1d×2.2d	1d	3d	Triangular with vertical face U/S	1.5d	1d	4d
4	MSM-14	1d×2.2d	1d	3d	Triangular with vertical face U/S	1d	1d	4d

5	MSM-15	1d×2.2d	1d	3d	Triangular with vertical face U/S	d/2	1d	4d
6	MSM-16	1d×2.2d	1d	3d	Triangular with vertical face U/S	1d	d/2	4d
7	MSM-17	1d×2.2d	1d	3d	Triangular with vertical face U/S	d/2	d/2	4d
8	MSM-18	1d×2.2d	1d	3d	Triangular with vertical face D/S	2.5d	1d	4d
9	MSM-19	1d×2.2d	1d	3d	Triangular with vertical face D/S	2d	1d	4d
10	MSM-20	1d×2.2d	1d	3d	Triangular with vertical face D/S	1.5d	1d	4d
11	MSM-21	1d×2.2d	1d	3d	Triangular with vertical face D/S	1d	1d	4d
12	MSM-22	1d×2.2d	1d	3d	Triangular with vertical face D/S	d/2	1d	4d
13	MSM-23	1d×2.2d	1d	3d	Triangular with vertical face D/S	1d	d/2	4d
14	MSM-24	1d×2.2d	1d	3d	Triangular with vertical face D/S	d/2	d/2	4d
15	MSM-25	1d×2.2d	1d	3d	Rectangular	1d	0.2d	4d
16	MSM-26	1d×2.2d	1d	3d	Rectangular	d/2	0.2d	4d
17	MSM-27	1d×2.2d	1d	3d	Square	1d	1d	4d
18	MSM-28	1d×2.2d	1d	3d	Square	d/2	d/2	4d

To observe the scour after the end sill of stilling basin, a erodible bed was made of coarse sand passing through IS sieve opening 2.36 mm. and retained on IS sieve opening 1.18mm. The maximum depth of scour (dm) and its distance from end sill (ds) was measured for each test after one hour run time to evaluate the stiling basin performance. The depth of flow over the erodible bed was maintained equal to the normal depth of flow. 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 was maintained. All the testing were performed for constant running time of one hour and with the same erodible material for two Froude numbers ie,3.85 and 1.85. Further scouring pattern was observed by using intermediate sill of different height and slopes, kept at the distance of 4d from the exit of the pipe with end sill. Thus total 36 test runs were performed to evaluate the performance of stilling basin. Scheme of experimentations are shown in Table1.

(b) **Performance Evaluation Criteria**

The performance of a stilling basin models were tested for different Froude number (Fr) which is a function of channel velocity (v), the maximum depth of scour (d_m) and its location from end sill (d_s). A non dimensional number, called as performance index (PI) has been used for comparison of performance of stilling basin models, Tiwari (2012 &2013). This is given as below:

$$PI = \frac{V x d_s}{2 d_m \sqrt{g \frac{\rho_s - \rho_w}{\rho_w} d_{50}}}$$

Where, V - the mean velocity of channel, d_s - distance of maximum depth of scour from end sill, d_m- depth of maximum scour, g – gravitation acceleration, ρ_s- density of sand, ρ_w density of water, d_{50}- the particle size such that 50% of the sand particle is finer than this size, A higher value of performance index indicates a better performance of the stilling basin model. The value of Performance index for various runs on each model for different Froude numbers are given in Table 2.

III.RESULTS AND ANALYSIS

To evolve the efficient and effective energy dissipator models for pipe outlet, 18 models, were tested for two Froude numbers, namely 1.85 and 3.85. The data pertaining to depth of scour and its location from end sill were collected for each model and reported in different tables to evaluate their performance. Performance of the basin models were tested with intermediate sill of different shapes like sloping, rectangular and square with varying height and slopes along with impact wall located at 3d and sloping end sill fixed at 8.4d. In model MSM-11, MSM-12, MSM-13, MSM-14 and MSM-15, height of sloping intermediate sill was varied from 2.5d, 2d, 1.5d, d and 0.5d respectively by keeping base width constant as 1d fixed at 4d with vertical face upstream. Values of performance index were computed and noted down in Table 2. Further by keeping base width 0.5d height was varied from 1d to 0.5d in model MSM-16 and MSM-17. Further, in model MSM-18, MSM-19, MSM-20, MSM-21, MSM-22, MSM-23 and MSM-24 vertical face of the sloping end sill was changed to downstream. After conducting the test and computing the values of performance index, variation of performance was shown in Table 2. After analysis it was found that by increasing the height of intermediate sill there is no improvement in the performance of the basin, as by increasing the height flow of water after intermediate sills flow a fall like structure by which scouring increases. It was also concluded that intermediate sill having vertical face stream performs better as compared to vertical face downstream. To improve the performance of basin further, models were tested with rectangular and square intermediate sill having height d and d/2 each. Tested models are MSM-25, MSM-26, MSM-27 and MSM-28. By looking the computed values of performance index (PI) as given in Table 2, It is found that model MSM-28 performs better as compared to other model tested so far in the basin length of 8.4d as its values of performance index (PI = 6.349 & 6.695) are higher side as compared to other models for both Froude numbers. Intermediate sill of suitable height promotes the dissipation of energy in the basin by lifting high velocity filaments from the bed.

Performance index models tested

Table 2

S. No.	Model name	Fr =1.85	Fr = 3.85
		PI	PI
1	MSM-11	5.32	4.419
2	MSM-12	5.872	4.577
3	MSM-13	5.948	4.790
4	MSM-14	6.745	4.900
5	MSM-15	6.838	4.882
6	MSM-16	7.937	4.800
7	MSM-17	6.512	4.224
8	MSM-18	3.55	3.881
9	MSM-19	3.460	3.973
10	MSM-20	4.370	3.947
11	MSM-21	4.593	4.396
12	MSM-22	5.189	5.031
13	MSM-23	5.155	3.879
14	MSM-24	4.409	3.872
15	MSM-25	5.19	5.131
16	MSM-26	6.309	6.10
17	MSM-27	8.411	5.466
18	MSM-28	6.349	6.695

IV. CONCLUSION

An experimental study was conducted in the laboratory by fabricating physical models to study the evaluation of the stilling basin performance for rectangular pipe outlets by using different size and shape of intermediate sill. Based on experimental results it is concluded that the shape of intermediate sill in a basin affects the performance of stilling basin significantly due to change in the flow pattern in the basin. During the study it was observed that the shape of intermediate sill affects the flow conditions and ultimately scour pattern downstream of the stilling basin. This study also revealed that the higher values of performance index indicate that the square intermediate sill enhanced the energy dissipation of flowing water and found to perform better for all flow conditions as compared to other intermediate sills tested for rectangular pipe outlet basin. The variation of performance index is due to the variation in flow geometry. It can be concluded from this study that by way of experimentation a proper shaped intermediate sill improve the stilling basin performance.

REFERENCES

[1.] Bradley, J.N., Peterka, A. J. (1957). Hydraulic Design of Stilling Basins. *Journal of A.S.C.E., Hydraulic Engg.* :vol. 83(5). pp.1401-1406.

[2.] Fiala, J. R. and Maurice, L. A.(1961). Manifold Stilling Basins, *Journal of A.S.C.E., Hydraulic Div. No 4*: Vol. 87. pp.55-81

[3.] Keim, S. R., Contra Costa Energy Dissipator. Journal of A.S.C.E., Hydraulic Division, 3077, March, 1962, pp. 109-122.

[4.] Vollmer, E., Khader, M.H.A., Counter Current Energy Dissipator for Conduit Outlets, International J. of Water Power, 1971, 23(7), 260-263.

[5.] Garde, R .J., Saraf, P.D., Dahigaonkar, D.J.(1986). Evolution of Design of Energy Dissipator for Pipe Outlets. *J. of Irrigation & Power* : vol. 41(3). pp. 145-154.

[6.] Verma D.V.S, Goel A. (2000). Stilling Basins for Outlets Using Wedge Shaped Splitter Blocks, *ASCE Journal of Irrigation and Drainage Engineering* : vol.126 (3) pp. 179-184.

[7.] Verma D.V.S., Goel A. (2003). Development of Efficient stilling basins for Pipe Outlets. *ASCE Journal of Irrigation and Drainage Eng.* :vol.129(3). pp. 194-200.

[8.] Negm, A.M. (2004). Effect of sill arrangement on maximum scour depth DS of abruptly enlarged stilling basins. *Proc. of Int. Conf. Hydraulics of Dams and River Hydraulics,* 26-28 April 2004, Tehran, Iran.

[9.] Goel, A., (2008). Design of Stilling Basin for Circular Pipe Outlet. *Canadian Journal of Civil Engineering* :vol. 35, No. 12, pp. 1365-1374.

[10.] Tiwari H.L., Goel A. and Gahlot V.K., (2011). Experimental Study of Sill Controlled Stilling Basins for Pipe Outlet, *International Journal of Civil Engg. Research.* : vol.2(2). pp.107-117.

[11.] Tiwari, H.L., Goel, A. and Gahlot, V.K., (2011). Experimental Study of effect of end sill on stilling basin performance, *International Journal of Engg. Sci. and* Technology: vol.3(4). pp.3134-3140.

[12.] Tiwari, H.L, Gahlot, V.K. and Tiwari Seema(2013). Reduction of Scour depth downstream of stilling basin. *International Research Journal of Engineering Sciences*: vol.2(7). pp.20-25.

[13.] Tiwari, H.L.and Gahlot, V. K. (2012). Experiments on new Stilling basin for Pipe outlets, *STM journal,* AISECT University, , Vol.1(2) .pp.17-20.

[14.] Tiwari, H.L. (2013). Design of Stilling Basin with Impact wall and End sill. *International Research Journal of Resent Sciences* :vol. 2(3). pp.59-63.

[15.] Tiwari, H.L.(2013). Analysis of Baffle wall gap in the Design of Stilling Basin Models, *International Journal of Civil Engineering and Technology* :vol. 4(4). pp. 66-71.