IIOAB JOURNAL
ISSN: 0976-3104

RESEARCH

COMPARING HYDRAULIC JUMP IN OGEE SPILLWAYS WITH DIFFERENT SLOPES

Mohammad Zare[1], Mohammad Shirvani[2*]

[1] Sama Technical and Vocational Training College, Islamic Azad University, Bandar Abbas Branch, Bandar Abbas, IRAN
[2] Young Researchers and Elite club, Kharameh Branch, Islamic Azad University, Kharameh, IRAN

ABSTRACT

Torrents have been recognized as main factor of destruction of structures and barriers in downstream of spillways of the dams. For this reason, one of the important issues which experts face is prediction of hydraulic jump. Although many studies have been conducted to reduce hydraulic jump and reduce torrent energy, most of them have been discussed for use of optimal spillways and slope of spillways. In this paper, hydraulic jump has been studied after performing laboratory model of the ogee spillways with two different slopes of 28 and 188 degrees. At the end, results of tests were compared in two slopes and it was concluded that length of hydraulic jump for flows of 7 and 9 l/s in slope of 28 degrees for ogee spillways of 60 and 70 cm and hydraulic jump length for the similar flows in slope of 18.8 degrees for ogee spillways of 45 and 65 cm. this has shown considerable reduction of hydraulic jump in slope of 18.8 when compared with slope of 28 degrees.

KEY WORDS
Ogee Spillways, Hydraulic Jump, Spillway Slope, Hydraulic Jump Length, Dam Spillway.

Published: 10 Sept 2016

***Corresponding Author**
Email:
m.shirvani@iauba.ac.ir

INTRODUCTION

One of the major factors of gradual destruction of hydraulic structures and the used barriers in downstream of dams and spillways is passage of torrents with high turbulence. High speed of passage through spillways of dams to downstream caused destruction and gradual erosion of the riverbed and can cause hazards for the structure. For this reason, stilling basins are mostly used to reduce kinetic energy of the flow in downstream of the dams. Length of the stilling basins embedded for reduction of hydraulic jump is a very important and determining factor [1,2].

In all stages of design and construction of spillways, all possible tools are used to reduce kinetic energy. The type ofused spillway is determining. In addition, reaching optimal slope of design for controlling hydraulic jump and reducing flow energy in construction of spillways are of the issues which attracted attention of many researchers [3].

Many studies have been conducted in the field of hydraulic jump in smoothbeds, for example, studies by Yarnell (1934), Patrika (1957), Rajaratnam (1967). Rajaratnam(1968) was the first person who studied hydraulic jump in the corrugated bed. he defined a parameter called K=Ke/y1(relative roughness) where Ke is EquivalentRoughness Height and y1 is depth of the initial inflow on rough bed. He showed that hydraulic jumps formed in rough beds were shorter than those formed in smooth beds. Ead and Rajaratnam (2002) conducted experimental study on hydraulic jump on the corrugated beds and showed that depth of the downstream fill required for hydraulic jump on the corrugated beds was lower than depth of the downstream fill required for jump on the smooth bed and also shear stress was almost 10 times as much as shear stress in smooth beds [4]. Characteristics of hydraulic jump on beds with rectangular tape roughness with two heights of 2.5 cm and t=1.5 and five spaces of block (s=1.5, 3, 4, 6, 7.5) in range of Froude numbers 3 to 10 were studied by Gohari and Farhoodi (2009). Based on results of this research, increase in space of blocks reduced secondary depth of jump. Change in height of roughness didn't have considerable effect on characteristics of hydraulic jump.

METHODS

Spillway of dams includes different types of geometrical shape. In this research, two types of ogee spillways have been studied in different slopes. Ogee or smooth spillways have a control overflow as ogee spillway or with S-shaped profile. The upper part of the curve is designed such that it can match with the lower profile of aquifer which has been aerated on a sharp-pointed overflow. Prevention of air into the aquifer causes contact between the spillway and spillway crest profile [5,6].

To design the best energy dissipation state, it was mentioned that steeped spillways in different slopes of 28 and 18.8 with edentate downstream spillway with height of 3 cm were studied to form hydraulic jump

IIOAB JOURNAL
ISSN: 0976-3104

in the experimental model. Then, results of tests and measurement of hydraulic jump for each optimal slope of spillway are discussed [7]. Most phenomena in fluids mechanics complexly depend on geometrical parameters and flow parameters. To understand each of the problems, effective parameters of each phenomenon should be evaluated [8,9].

Modeling

An experimental set which includes a channel, spillway and stilling basin in downstream has the following facilities: stilling basin in upstream of channel, spillway glassy channel with width of 20cm, length of 4m and glassy walls with height of 50 cm with slope variability, horizontal channel of the basin with depth of 40 cm in the free edge with width of 20 cm and length of 4m , downstream basin of the channel with dimensions of 3.5 m in 3 m and depth of 70cm with 10 cm free edge , centrifuged pump with maximum discharge capacity of 60l/s in height of 10 m , gate valves with diameter of 10 cm (4 inches) with general length of 11.5 m. to measure different parameters of flow along spillway channel and sandy channel, the following facilities were used : magnetic flow meter, electronic altimeter, magnetic floater altimeter in downstream basin , triangular spillway, clinometers, piezometer of the stilling basin in upstream of spillway channel.

The experimental model will be conducted by changing the slope, height, tread and riser of stair, and also the dentations which have been created at the end of the downstream route [10,11].

In the first test, steeped spillway was placed in slope of 28 degrees and placed at the end of the downstream spillway to create dentated hydraulic jump with height of 3 cm. Change in flow directed hydraulic jump to spillway to measure parameters of jump such as length of jump and secondary height. Then, to measure parameters in the second test, steeped spillway slope was reduced to 18.8 degrees with the same dentated height of 3 cm and parameters of hydraulic jump were studied and measured. Results of both tests for calculation of parameters of hydraulic jump are shown in Tables 1 and 2.

Table 1: Specifications of hydraulic jump with steeped spillway with slope of 28 degrees and dentation of 3 cm

Flow (lit/sec)	Initial depth (cm)	Secondary depth (cm)	Length of roller (cm)	Jump length (cm)	Jump location (cm)	Fr_2	Lj/Y2
7	3	7	25	60	145	0.6	8.57
9	4.1	7.4	35	70	245	0.7	9.46
11	0	0	0	0	0		

Table 2: Specifications of hydraulic jump with steeped spillway with slope of 18.8 degrees and dentation of 3 cm

Flow (lit/sec)	Initial depth (cm)	Secondary depth (cm)	Length of roller (cm)	Jump length (cm)	Jump location	Fr_2	Lj/Y2
7	3	7	15	45	70	0.6	6.43
9	4.2	7.5	20	64	170	0.7	8.6
11	5.8	7.7	25	70	230	0.82	9
13	0	0	0	0	0		

RESULTS

As shown in Table 1, hydraulic jump in flow rates of 7 and 9 l/s was created with the mentioned specifications but in higher flow rates, hydraulic jumps have been created in 4 m of downstream. Therefore, it is not measurable and range of flow rates is low.

Considering changes and information taken from Table 2, it can be found that length of jumps and sometimes length of roller has been reduced with steeped spillway with slope of 28 degrees and dentation of 3 cm. in this case, for flow rates of 7 and 9 l/s, roller length has been reduced from 25 and 35 cm in slope of 28 to 15 and 20 cm for similar flow rates. As length of hydraulic jump was calculated and extracted for flow rates of 7 and 9 l/s in slope of 28 degrees for ogee spillway of 60 and 70 cm and length of jump for similar flow rates has been calculated as 45 and 65 in slope of 18.8 degrees.

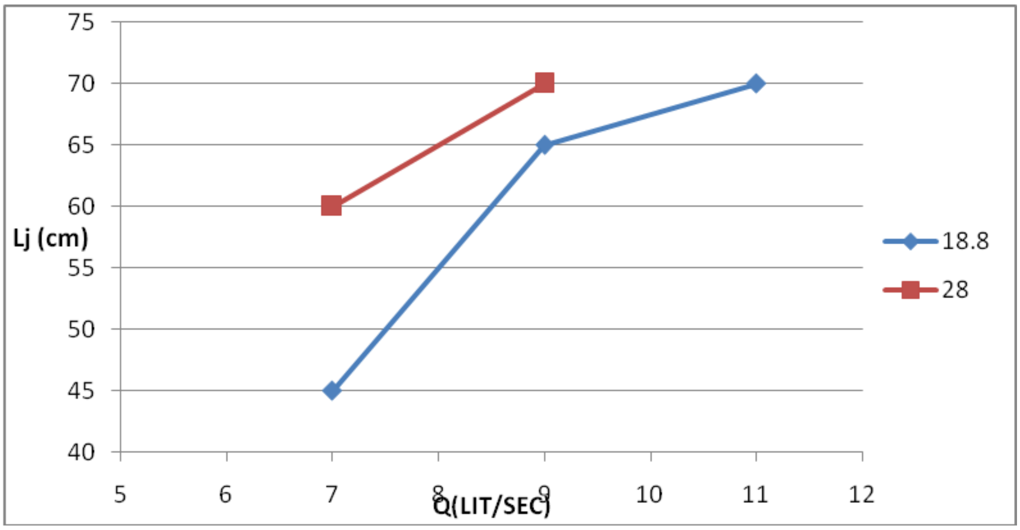

Fig. 1: Steeped spillway with fixed dentation of 3 cm with slope of 18.8 and 28 degrees

As it is estimated in Diagram 1, comparison of results of both spillway tests with slopes of 28 and 18.8 degrees shows slope of 18.8 as the second tests of roller length and lower jump length compared with the first test of spillway with slope of 28 degrees.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGEMENTS

None.

FINANCIAL DISCLOSURE

None.

REFERENCES

[1] Abbaspour A., HosseinzadehDalir A., Farsadizadeh D., and Sadraddini A.A. [2009]. Effect of sinusoidal corrugatedbed on hydraulic jump characteristics. Journal of Hydro-environmental Research 3: 109-117.

[2] Abrishami J,.andSaneie M. [1994]. Hydraulic jump in adverse basin slopes. Int. Journal of Water Research Engineering 2(1): 51-63.

[3] Ahmadi H. and Ilkhani R. [2004]. Studying hydraulic jump in experimental model of Pfeiffer with pore without lateral compression. The second national student conference on water and soil resources. Faculty of Agriculture of University of Shiraz.

[4] Ead S.A., and Rajaratnam N. [2002]. Hydraulic jumps on corrugated beds. Journal of Hydraulic Engineering ASCE128 (7): 656-663.

[5] Beirami M. K. and IlaghiHosseini M., [2004]. Controlling hydraulic jump with one or two extended walls in horizontal stilling basin. Esteghlal Journal. 24.

[6] Beirami M.K., and Chamani M.R. [2006]. Hydraulic jumps in sloping channels: sequent depth ratio. Journal of Hydraulic Engineering, ASCE 132(10): 1051-1068.

[7] Bradshaw, p. [1997] " The understanding and prediction of turbulent flow.". Int J Heat Fluid Flow.

[8] Craft TJ, Launder BE, Suga K. "Development and application of a cubic eddy" viscosity model of turbulence."Int J Heat Fluid [1996]; 17:108-15

[9] Dey S., and Sarkar A. [2006]. Response of velocity and turbulence in submerged wall jets to abrupt changes from smooth to rough beds and its application to scour downstream of an apron, Journal of Fluid Mech, 556:387–419.

[10] Esmaeili Varaki M. [2003]. Studying characteristics of divergent hydraulic jump in trapezoid sections. M.S. thesis of hydraulic structures. Irrigation Department . University of Tehran.

[11] Omid M.H. [1997]. Hydraulic jump in trapezoid sections. Iran Agricultural Sciences Journal. 3.