LATERAL CHUTE AND JET IMPACT FOR OGEE SPILLWAY

SEYED MAHMOOD BORGHEI[1] and AFSHIN AHMADI[2]

[1]Associate Professor, Civil Engineering Department, Sharif University of Technology,
P.O. Box 11365-9313, Azadi Ave., Tehran, IRAN
(Tel: +98-21-6005818, Fax: +98-21-6014828, e-mail: mahmood@sharif.edu)
[2]PhD Student, Civil Eng. Dept., University of Tehran.

Different kinds of spillways are used to convey flood through reservoirs to downstream river. The most popular of these structures are; chute spillway, side channel spillway, siphon spillway, stepped spillway, tunnel spillway and shaft spillway [Novak et al., 1990]. On the other hand, due to high energy at downstream of spillways, stilling basins and plunge pools are the most efficient way to loose a great amount of energy and, hence, a less turbulent flow continues downstream. While plunge pools are mostly used for high dams, for small dams stilling basins are more conventional. Usually, in conventional designs, stilling basin has the same width as the spillway which would be costly and, hence, a constrain for this kind of energy dissipater structure.

Overall, there can be five different stages due to energy dissipation from top of the spillway to the downstream river [Novak and Cabelka, 1981]. As shown in Fig.(1), these are; friction on the spillway chute, air resistance due to ski jump, jet impact to the pool, hydraulic jump in the basin and loss due to turbulence after the jump and into the stream. For stilling basin, other measures can be taken in order to increase energy loss efficiency. Among them, stepped chute spillways or weirs which are a kind of spillway that the turbulence on the spillway due to steps help reducing the energy [Chanson, 1994a, Chanson, 1994b, Chamani and Rajaratnam, 1994, Tozzi 1994]. Also, jet impacts on the spillway or just before entering stilling basin (or impact in the air in case of ski jump) introduces more turbulence and, therefore, extra energy loss [ICOLD, 1987].

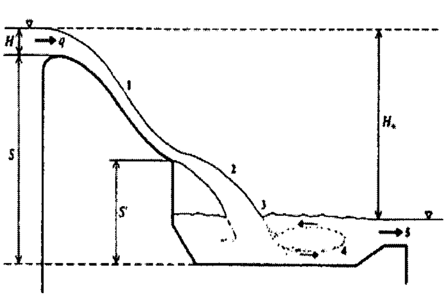

Fig. 1 Five stages of energy dissipation on a spillway and stilling basin [Novak and Cabelka]

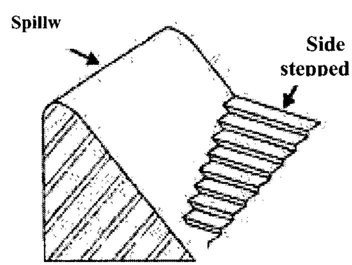

Fig. 2 Schematic of a side or lateral stepped chute

The effect of jets impact in the air, on the chute or basin as a means of energy dissipation have been an interesting subject for many researchers. Lencastre (1987), has studied experimentally the energy dissipation potential of jets impact.

Combinations of some of the aforementioned methods can be used to increase the energy loss effect of the spillway and, therefore, design of smaller stilling basins. Thus, in this paper, experimental model of the combined three designs (i.e.; lateral chute, stepped chute and jet impact) have been used for a conventional ogee spillway. Lateral chutes parallel to the crest spillway, with and without steps (Fig. 2), have been used together with jets impact at the foot of the spillway from opposite directions and the spillway flow at the same. The aim of the research is to observe the effect of this kind of compound spillway on downstream Froude number as well as its ability to energy loss respect to the conventional spillway.

The tests were carried out in a masonry channel 100 cm width with an ogee spillway the same length (b_t=100 cm) and 50 cm height. The geometry of the spillway was for discharge design (Q_d) of 100 lit/s. Side channel chute with top and bottom width of 22 and 10 cm respectively and slopes of (H:V) 1:4, 1:3, 1:2.5, 1:2 and 2:3 were used (or five downstream channel widths b=25, 33, 40, 50 and 70 cm). Three kind of chute roughness; without steps (WS), with small steps (SS) and with large steps (LS) and 7 different discharges were tested.

The experimental model of the compound spillway with side channel chutes show that the relative energy loss can be increased by 20%. However, the effect of symmetrical side channel chutes on Froude number at the toe of spillway is quite appreciable. While for conventional spillway, Froude number (for all discharges) was about 6, it reduces to less than a third, as shown in Fig. 3. In a way that the stilling basin can have quite a different design and dimensions as the type of stilling basin is selected according to Froude number. Finally, the important result from the tests is that the optimized downstream width relative to the spillway width has been found to be 40%, as in Fig. 4. This study shows that this kind of compound spillway can be designed and used as a mean of optimized hydraulic structures (spillway and stilling basin). Since different designs are possible, hence, for the final design of such structures the hydraulic model is recommended.

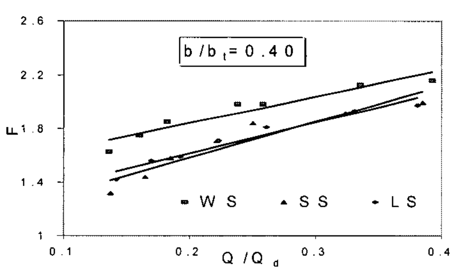

Fig. 3 Froude number at the toe of spillway due downstream channel width or lateral chutes

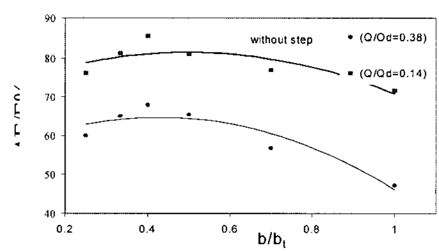

Fig. 4 Effect of downstream chann width to on energy dissipation

REFERENCES

Chamani, M.R., and Rajaratnam, N. (1994). Jet Flow on Stepped Spillway. J. of Hydr. Eng., ASCE, Vol. 120, No. 2.

Chanson, H. (1994a). Hydraulic Design of Stepped Cascades, Channels, Weirs and Spillways. 1st Pupl., Pergamen.

Chanson, H. (1994b). Comparison of Energy Dissipation Between Nappe and Skimming Flow Regimes on Chutes. J. of Hydr. Res., IAHR, Vol. 32, No. 3.
ICOLD. (1987). Spillways for Dams. Bulletin 58.
Lencaster, A. (1987). Cross-jets a Solution for Increasing Discharge Capacity of Spillways. 15th ICOLD, Q. 59-R. 26, Vol 4.
Novak, p., and Cabelka, J., (1981). Models in Hydraulic Engineering – Physical Principles and Design Applications. Pitman, London.
Novak, P., Moffat, A.I.B., Nalluri, C., and Narayanan, R., (1990). Hydraulic Structures. 1st Publ., Unwin Hyman Ltd., London.
Tozzi, M.J. (1994). Residual Energy in Stepped Spillway. J. of Water Power and Dam.