REDUCTION IN LENGTH OF STILLING BASIN BY PROVIDING DEPRESSION IN THE HORIZONTAL APRON

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ABSTRACT

This paper aims at reducing the length of Stilling basin by providing a depression of specific dimensions in the basin floor. The experimentation is going on in the Fluid Mechanics Laboratory of B.V.D.U.C.O.E. Pune - 43. As we know, by reducing the area of flow, the post jump depth can be increased and thus the jump can be confined within the length of apron. Though the ideal location for the jump is the proximity of toe of spillway or sluice gate, the location get disturbed due to variation of discharge. In this context a remarkable thing has been observed while experimentation. Initially, the forced jump was formed in the laboratory flume by using the obstruction strips as downstream control and that too without any depression in the floor. But after activating a depression of certain size, the jump was observed to be moved on upstream side. And the obstruction strips were needed to be shifted on upstream towards the depression to maintain the location of jump. Thus the experiments have been carried out for different sizes of depressions, and it was found that there is perfect relationship between the size of depression and the location of downstream control corresponding to the same location of jump. It was noted that the length of stilling basin can be reduced by providing a depression of certain size in the basin floor.

INTRODUCTION

As we know, the hydraulic jump type energy dissipators have been in most common use since vary long times. Till date lot of modifications took place in the design of such type of dissipators. Amongst various components, the stilling basin apron is the most important one, which is horizontal in most of the cases. Moreover it is a vary costlier matter one has to deal with. It is well known that the ideal position for the jump to occur is near the toe of spillway. But variation of discharge badly affects the location of jump and hence the performance and the successive energy dissipation. Thus the effort have been made to suppress the influence of variation of the discharge on the location of the jump. If we specially talk of the tail water deficiency condition, the end sill or the dentated sill may be provided with the aim of boosting up the post jump depth and forming the jump within the length of the apron itself.

ABOUT THE PROPOSAL

Now one of the traditional ways to increase the post jump depth is to increase the height of the end sill. But this will not serve the purpose at low discharge, as there will be every chance of submergence of the jump. Thus this constraint poses the limitation over the increase in height of the end sill. Thus keeping with this fact, we have directed our efforts towards creating same effects which are obtained by boosting of the post jump depth without increasing the height of the end sill on down stream. The idea is to provide the depression of certain size in the horizontal apron and that too in a zone of sub critical flow. This will cause some loss of momentum i.e. against the basic assumption in the hydraulic jump theory, which result in a reduction of the required post jump depth. It can be best demonstrated with the help of specific force and specific energy diagram.

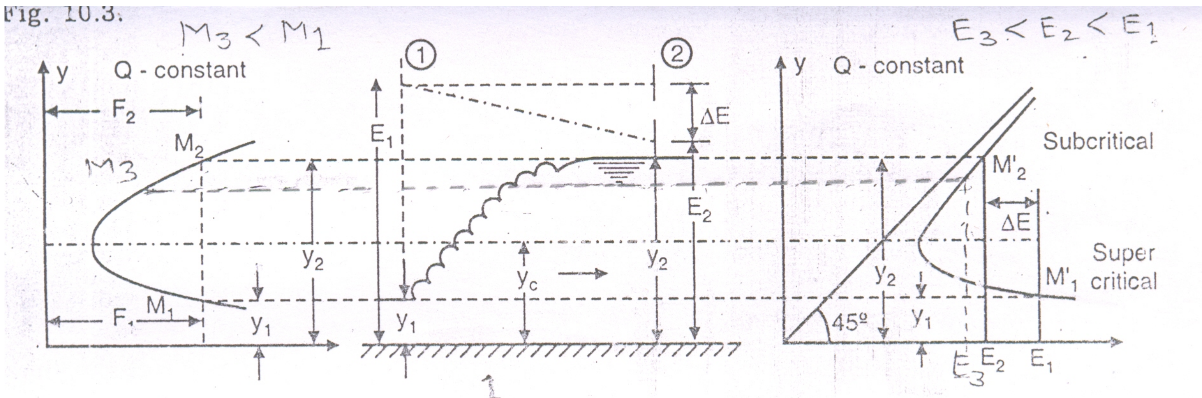


Fig. 1: Loss in Hydraulic Jump

The theory of hydraulic jump is based on the assumption of conservation of momentum, but like energy loss if we allow some momentum loss to occur then it will be accompanied with an additional loss of energy and this energy loss will go on increasing with the increase in loss of momentum. The corresponding post jump depth required to form the jump at some particular location will go on decreasing. Because of this, the specific energy of sub critical flow will go on decreasing whereas the specific energy of the incoming supercritical flow remains unchanged. Therefore, the difference between the specific energy before and after the jump will go on increasing or in other words the loss of energy will go on increasing. Furthermore it seems to be a new approach, slightly deviating from the conventional things.

ABOUT THE EXPERIMENTATION

Experimentation has been carried out in the fluid mechanics laboratory of Bharati Vidyapeeth's College of Engineering, Pune. As shown in following figure, following is the list of details of the experimental setup along with horizontal rectangular channel.

A. Length of flume = 10 m
B. Width of flume = 30 cm
C. Height of flume = 50 cm
D. Head on up stream of sluice gate = 1.3 m
E. Maximum possible discharge = 35 lps
F. Depression size = 60 X 30 X 12 cm deep
G. Location of depression = 4 m down stream of sluice gate
H. The depression has been created by raising by the channel bottom by 12 cm height by means of acrylic platform
I. Initial location of down stream control w/o the effect of depression = 8.12 m down stream of sluice gate

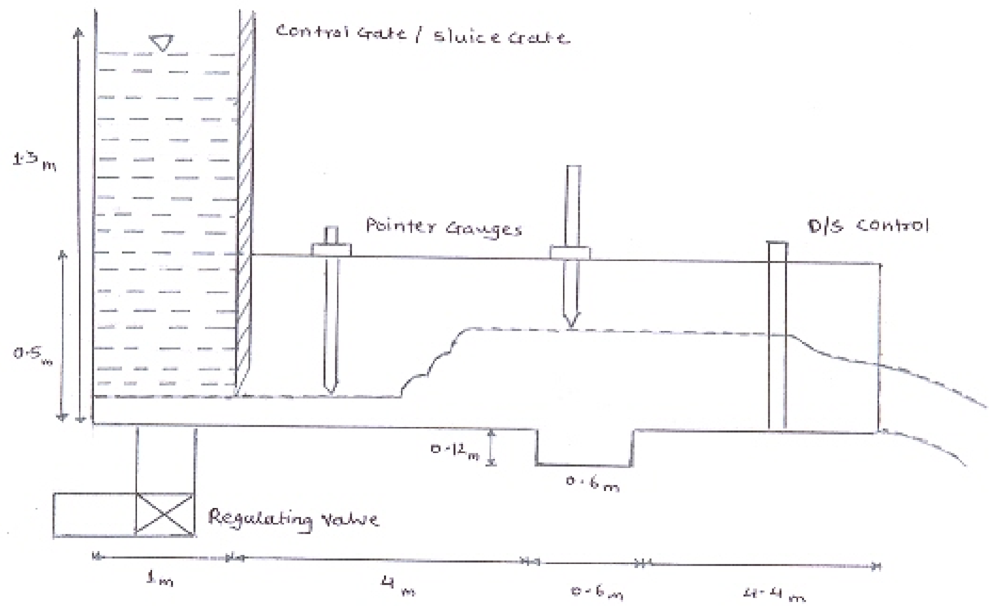
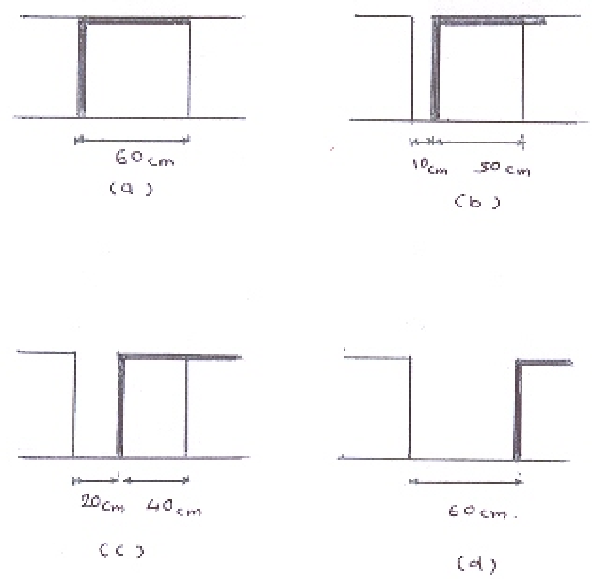


Fig. 2: Tilting Flume with experimental setup & depression

STRATEGY OF THE EXPERIMENTATION

As usual with a gate opening of 4.47 cm and with the appropriate down stream control located at a distance of 8.12 m down stream of a sluice gate, the hydraulic jump has been formed at a distance of 3 m down stream of a sluice gate. During this process the depression has been kept closed with the help of special type of 'L' shaped lid fabricated in plywood. The jump resembles to classical hydraulic jump formed on a horizontal floor of a rectangular channel. It is also essential to note that if we change the location of down stream control, the location of the jump also get disturbed. After this the lid has been shifted on down stream by a distance of 10 cm to activate the depression of size 10 X 30 X 12 cm deep as shown in figure 3. Thus in other words, as compare to the total size of depression, the 16.67 % of depression is opened. Because of this the jump was found to be shifted slightly on upstream. Thus to bring the jump back to its initial location, the down stream control was needed to be shifted in up stream direction by a distance of around 15 cm.

The same process is then followed for different sizes of depression openings e.g. length of opening of the depression ranging in an order of 20 cm, 30 cm, 40 cm & 60 cm (i.e. depression fully opened). For each of these cases the model was required to be shifted on up stream, the details of which are given in the following observation table.



(a) Depression fully closed. (b) Depression 10 cm opened.
(c) Depression 20 cm opened. (d) Depression fully opened
Fig 3: Depression with Different Lid positions

EXPERIMENTAL OBSERVATION

A. Head over Rehbock weir = 9.6 cm
B. Discharge Q = 25.12 lps
C. Gate opening = 4.37 cm
D. Supercritical depth (y_1) = 4.47 cm
E. Sub critical depth (y_2) = 17.46 cm
F. Specific energy before jump (E_1) = 0.2235 m
G. Specific energy after jump (E_2) = 0.1863 m
H. Loss of energy $\Delta E = E_1 - E_2$ = 0.0372 m
I. Froude number before jump (Fr_1) = 2.828

OBSERVATION TABLE

Sr. no.	y_1 (m)	y_2 (m)	v_1 (m/s)	v_2 (m/s)	E_1 (m)	E_2 (m)	$\Delta E = E_1 - E_2$	%ΔE	Fr_1	Width of opening (m)	Distance of d/s control from 3.42 m d/s of the end of the depression (m)
1	0.0447	0.1746	1.8732	0.4795	0.2235	0.1863	0.0372	16.645	2.828	0	0
2	0.0447	0.1699	1.8732	0.4928	0.2235	0.1822	0.0413	18.478	2.828	0.1	0.15
3	0.0447	0.1672	1.8732	0.5007	0.2235	0.1799	0.0436	19.507	2.828	0.2	0.40
4	0.0447	0.1289	1.8732	0.6495	0.2235	0.1504	0.0731	32.706	2.828	0.3	1.04
5	0.0447	0.1328	1.8732	0.6305	0.2235	0.1530	0.0705	31.543	2.828	0.4	1.87
6	0.0447	0.1312	1.8732	0.6382	0.2235	0.1519	0.0716	32.035	2.828	0.5	2.82
7	0.0447	0.1308	1.8732	0.6401	0.2235	0.1516	0.0719	32.170	2.828	0.6	3.52

ANALYSIS OF EXPERIMENTAL RESULTS

It has already been mentioned before that due to the presence of depression in the horizontal apron, the post jump depth y_2 required to form the jump at predefined location, get reduced. Thus because of this, length of jump which is calculated as:

$$L_j = 6.9\ (y_2 - y_1)$$

also get reduced and this is the reason why the length of stilling basin get reduced. Because the stilling basin length is design based on the length of hydraulic jump corresponding to the maximum discharge under consideration. And here in this case we are reducing the length of hydraulic jump itself. Thus the reduction in the length of stilling basin may be consider to be the combined effect of reduction of y_2 and then reduction of length of hydraulic jump.

ECONOMIC CONSIDERATION

As has been mentioned earlier, the horizontal concrete apron of the stilling basin is a vary costlier matter. Now it is already seen that by providing a depression of a certain size and that too at certain location, we can reduce the length of stilling basin. Secondly the depth of depression may be designed in such a fashion that it can be merged in the thickness of apron itself or very little excavation is required. Furthermore it will also cause the direct reduction in the volume of concrete almost equal to the volume of depression itself. Thus the advantage of provision of depression is twofold.

CONCLUSIONS

1. The concept of loss of momentum could be very well observed and found to be occurred due to presence of depression in the horizontal floor of the apron.

2. Due to the loss of momentum an additional loss of energy (apparent) occurs and simultaneously it suppresses the requirement of post jump depth which is essential to form the hydraulic jump at predefined location.
3. Thus the net effect of the provision of depression is slight increase in energy loss and reduction in the length of stilling basin by way of reduction in the length of jump due to the reduced post jump depth.
4. As the concept of loss of momentum is some what new, further exploration in this regard is necessary and seems to be optimistic.

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