STUDY OF SEDIMENT DIVERSION THROUGH BRANCH CHANNEL USING OBLIQUE WEIR

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Key words: *dividing streamline, discharge division, sediment division, oblique weir, vortex*

1.INTRODUCTION

Sediment deposition at the reservoir causes the depletion of the storage volume, which in turn affects the effective functioning of its set purposes. If the reservoir gets silted up, the whole project have either to be abandoned or have to rely on recovery technique, which could be very expensive in practice. During process of the reservoir sedimentation, exist various leading factors causing sedimentation, which have the weightage input depending upon the particular field condition. Although the life expectancy of the reservoir could not be extended for the long period, with the proper sediment management at the upstream watershed area, reservoir sedimentation process could be little much slowed down. Among the various sediment management techniques, sediment bypassing is also one of the effective countermeasures for the reservoir sedimentation.

Research was carried out in order to achieve bypassing of maximum of the incoming sediment with the minimum loss of the useful water during the diversion. With reference to the various past studies (Bulle[1)], Kudoh[2)]), it was understood that the dividing streamline at the bottom of flow has the leading role during the diversion process of the bed load, which contributes the major portion on the reservoir sedimentation. The width of the bottom dividing streamline (b_b) was found to be depending upon incoming flow condition, ratio of depth of main to the branch channels (d_3/d_1), aspect ratio (defined as the ratio of depth of incoming flow to the width of the branch channel) and bed roughness (Neary[3)]). b_b was found to be wider when the incoming Froude Number(F_1) was low and decreased with the increment of the F_1.Similarly b_b was wider in the case of flow with large aspect ratio even in the similar F_1. For the channel junction with the small width ratio of main to the branch channel (Bulle[1)]), maximum of the sediment could be diverted in to the branch channel. In the case of junction with the larger width ratio only the portion of the incoming sediment could be diverted along with the flow. Study was carried out to understand the effect of construction of the flow modifying structure (oblique weir) across the river channel on diversion of the incoming sediment. Spiral vortex formed along the upstream wall of the oblique weir was studied for the various upstream flow conditions, which caused the incoming sediment located beyond the bottom dividing streamline made to move towards the branch channel.

2.EXPERIMENTAL STUDY

Experiments were carried out at the rectangular channel of 45 cm and branch channel of 3.8 cm widths. Junction intersection was made of 30° and both the channels were of horizontal slopes. Bottom of main channel was made of rough by sticking the sand passing through the sieve of mesh size 0.9 mm. Oblique weir was placed across the main channel at 45° and experiments were carried for the various heights of weirs (3 cm, 5 cm, 7 cm, combination of 5 and 7 cm) and flow conditions. Incoming flow discharge was measured through calibrated V-notch

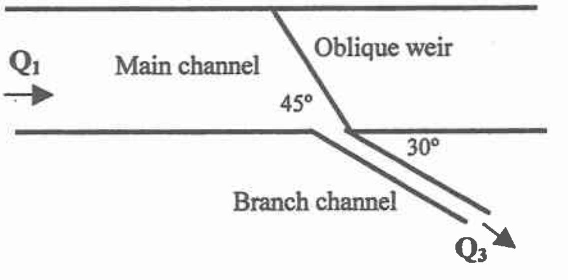


Fig. 1 Schematic diagram

and branch flow by bucket and stopwatch. Similarly, percentage of sediment diverted in to the channels was measured through the measuring bucket. For the simulation of the incoming sediment, plastic pellets with cylindrical shape having length and diameter of 3 mm in size and specific weight 1.20 were used. Feeding of pellets was done manually considering weir is about to fill up to the crest level.

3.FLOW AND SEDIMENT DIVISION AT THE JUNCTION WITHOUT WEIR

Discharge division relation for the 30^0 open channel junction with the free flow condition at the branch channel was developed (Lama[4]) with the mass and momentum equation and could be calculated with the simple expression (Eq. 1) with the known value of F_1 and d_3/d_1. Figure 2 shows the plot of the theoretical curve compared with the measured data for 1:4 junction for the flow condition having different aspect ratio.

$$F_3 = \sqrt{\frac{\left(0.40+0.4\frac{d_3}{d_1}-0.72\left(\frac{d_3}{d_1}\right)^2\right)}{C_c\left(\frac{d_3}{d_1}\right)^2}}$$

$$\frac{Q_3}{Q_1} = \frac{b_3}{B}\frac{F_3}{F_1}\left(\frac{d_3}{d_1}\right)^{\frac{3}{2}} \qquad (1)$$

Where, F_1-Froude Number of flow at the main channel, F_3-Froude Number at the branch channel, d_3/d_1-ratio of flow depths at branch to the main channel, Cc-Coefficient of contraction of flow at the branch channel which could be taken as 0.95,Q_3-quantity of flow entering in to the branch channel,Q_1-Quantity of incoming flow ,b_3-width of the branch channel, B-width of the main channel

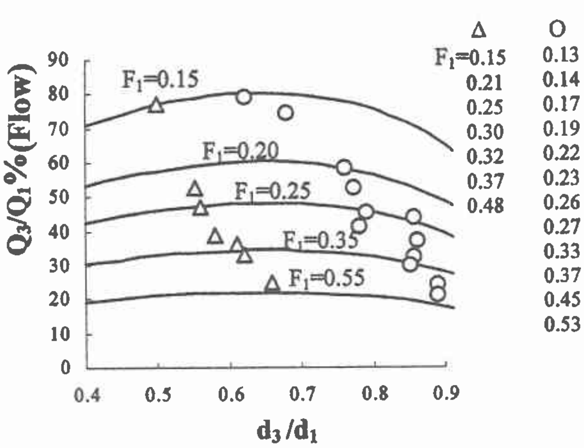


Fig.2 Theoretical relationship for discharge division for 1:4 junction, symbol Δ (4.5 cm branch) and O (10 cm branch) shows the measured data plotted from above to down

Kudoh [2] in his work reported variation of the ratio of percentage division of the sediment (Q_{sr}) to the division of flow (Q_r) for the 30^0 junction intersection. This ratio was reported to be decreasing with the increase of F_1. (Fig. 3)

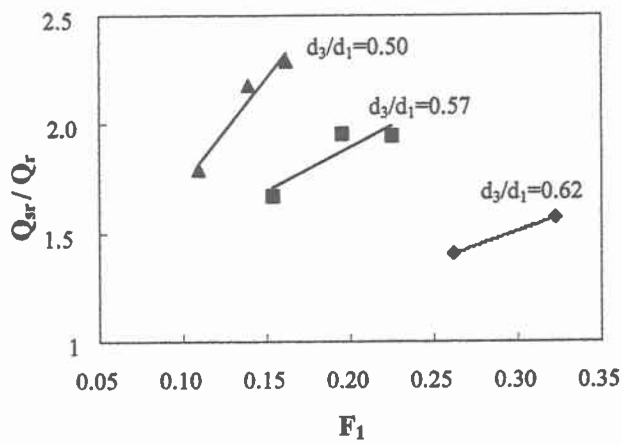


Fig. 3 Variation of the sediment and flow division with the F_1

4.VARIATION ON FLOW AND SEDIMENT DIVISION DUE TO WEIRS

In the case of flow without weir, flow division was found to be not much varying with the variation of d_3/d_1 (Fig.2) but found to have effect on the diversion of sediment in to the branch channel when comparing with similar F_1. When comparing the flow division with and without weir, it was found that flow quantity entering in to the branch channel did not vary with each others when compared with the similar flow condition. With the variation of weir heights percentage distribution of flow entering in to the branch was found to be slightly increasing when compared with the similar F_1, but the variation in sediment diversion was found to be significant. With the presence of weir, d_3/d_1 was found to be not much varying with the flow condition so F_1 was taken as the main parameter for the comparison of the measured data for different weir heights. (Fig 4, 5)

Table 1

Weir height ,cm	h_1 cm	F_1	Flow Q_3/Q_1%	Sediment Q_3/Q_1%
3	5.72	0.25	12.2	28
	6.45	0.35	9.2	25.7
	6.95	0.42	8	22
5	7.93	0.24	14.1	52
	9.05	0.34	10.9	50
7	10.35	0.25	14.7	≈90
5 & 7	8.55	0.16	21.9	≈90
	9.9	0.25	14.3	≈90

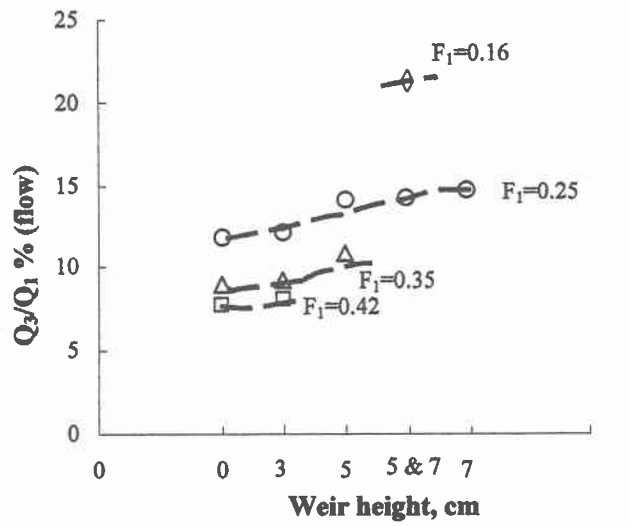


Fig. 4 Variation of flow division with F_1 for weirs of different heights

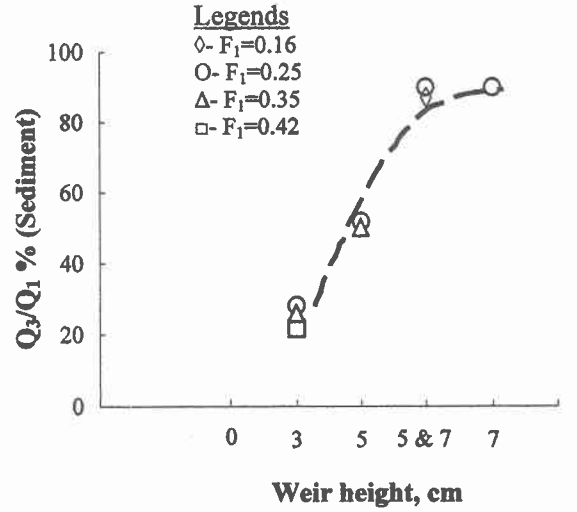


Fig. 5 Variation of sediment division with F_1 for weirs of different heights

5. MECHANISM OF DIVERSION

Formation of the vortex behind the oblique weir was analyzed for the study of diversion of the sediment through the branch channel. The spiral vortex train moving along the wall of the oblique weir cause the incoming sediment beyond the bottom dividing streamline move towards the branch channel. The strength and translation of vortex along the weir was found to be depending upon the height of the weir (Pic.1, 2, 3,4). Incoming sediment inside the bottom dividing streamline will apparently enter in to the branch channel and beyond that pass over the weir. For the weirs with height 3 and 5 cm, translation of vortex were found to be not reaching to the dividing streamline (Fig.6, Pic. 1,2) so portion of the sediment had passed over the weir.

If the translation vortex could reach to the dividing streamline (Fig.7, Pic.3,4) then maximum of the sediment will enter in to the branch channel. For the case of the weir with 7 cm height, vortex formation was found to be of much strength and due to that some of the sediments were flown over the weir. For 7 cm weir, vortex formation pattern and quantity of sediment entering in to the branch channel did not differ much if the height of the right half portion of the weir was reduced (Fig7) to 5 cm. Quantity of flow entering in to the branch channel and upstream water depth was found to be less in this case when compared for the same incoming flow quantity (Q_1). As the vortex may cause the scouring along the bottom of upstream side of weir and around the intake area, protection work is necessary for such sediment diversion structure.

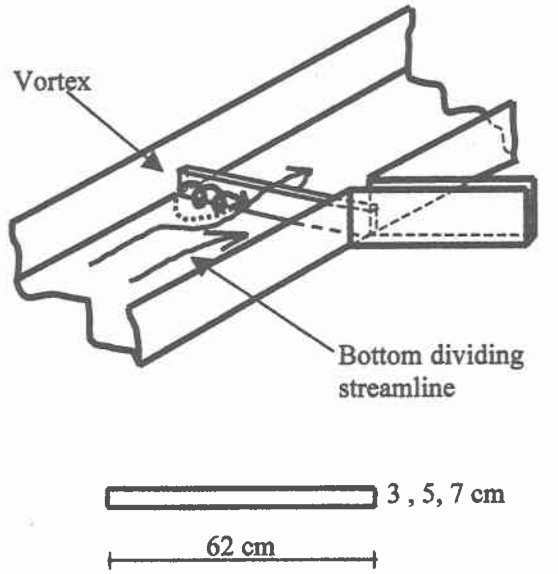


Fig. 6 Oblique weir with uniform weir height

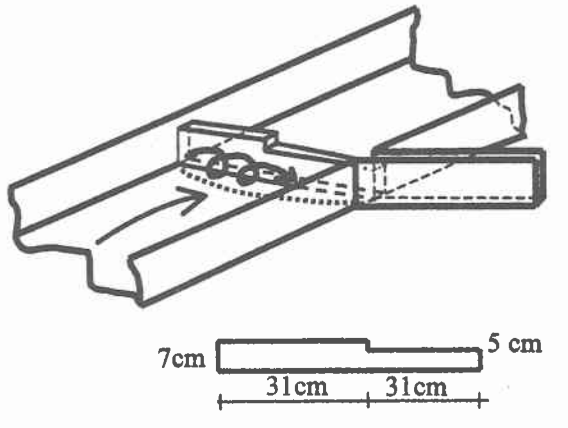
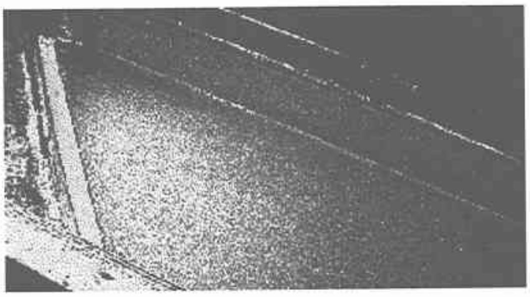
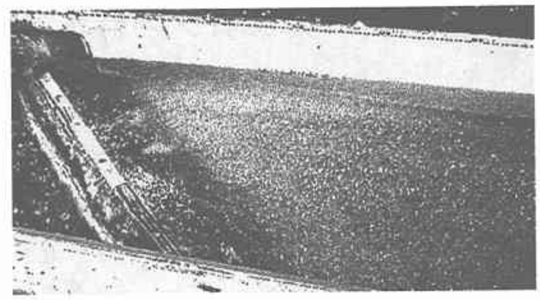


Fig. 7 Oblique weir having combination of weir height

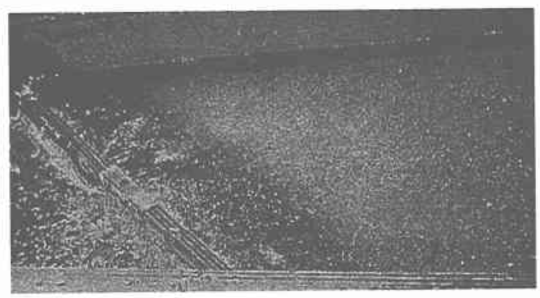


Pic. 1 Weir height =3 cm



Pic. 3 Weir height = 7 cm

Pic. 2 Weir height =5 cm



Pic. 4 Weir height = combination of 5 and 7 cm

6.CONCLUSION

For the purpose of the maximum sediment diversion through the wide rivers with the minimum loss of the useful water, it is necessary to have the flow modifying structure. Among the various sediment diversion techniques, oblique weir could also be used for that purpose. Spiral vortex developed along the upstream of the oblique weir cause the incoming sediment move towards the branch channel. Strength of the vortex and translation of vortex along the weir was found to be increasing with the increase of the weir height. With the presence of weir, percentage of the sediment entering in to the branch channel was found to be increased whereas flow quantity was not much varied when compared with the cases without weir.

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