Flow characteristics at 30° open channel diversion with free flow at branch channel

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1) Introduction

Sediment diversion through the bypass channel could be one of the appropriate techniques for sediment management in the field of water resources utilization. Different flow characteristics occurring at the open channel junction varies with the variation of flow condition at the junction. One of the main flow characteristics, which have direct influence on the sediment and flow diversion, is the bottom dividing streamline (Fig. 1). It was found to be wider in the case of the incoming flow with low Froude Number (F_1) and goes on decreasing with the increase of F_1.So there is possibility of entrance of much flow and sediment in to the diversion channel in the case of low F_1 than compared with the higher value of F_1.It was also observed that flow condition at the junction with free flow condition at branch channel are similar to each other without respect to different width ratio of main to the branch channel [(4)].

2) Flow characteristics at the junction

Experiments were carried out at the hydraulic flume of 8-meter length with 30° branch at 3-meter from the start of the main channel with the different widths of main to the branch channel. Both main and the branch channel were almost horizontal and flow condition at the junction was varied either varying the gate height at the downstream of the main channel or varying the incoming flow discharge (Q_1). Bottom of the main channel was made rough by sticking sand passing through the sieve size of 0.9 mm opening.

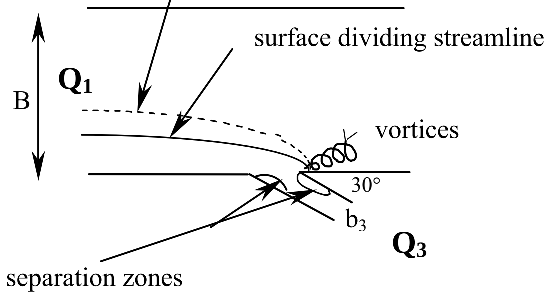

Fig. 1 Schematic diagram of junction flow

In the case of flow with low F_1, bottom dividing streamline didn't end directly at the edge of the downstream wall of the branch channel at the junction but extended little ahead having the curve path along the main channel and returned back causing flow to be separated along the downstream wall of the branch channel. This curve path of bottom dividing streamline was straightening as the F_1 increased and due to that separation zone along the downstream wall of the branch channel started vanishing. Separation zone forming along the branch channel was also found to be varying with the aspect ratio (d_1/b_3-defined as the ratio of depth of flow at main channel to width of the branch channel). In the case of experiments with F_1 around up to 0.30 with aspect ratio greater than 1.00, flow separation was found to be forming only along the downstream wall of the branch channel where as in the case of experiments with aspect ratio less than 1.00, it was found to be forming along both the walls of the branch channel. In case of the flow condition with aspect ratio greater than 1.00, curve flow surface forming at the branch channel had the suppress effect along the upstream wall of the branch channel, so separation zone only formed at the downstream wall of it and this suppress effect decreased with the decrement of the aspect ratio.

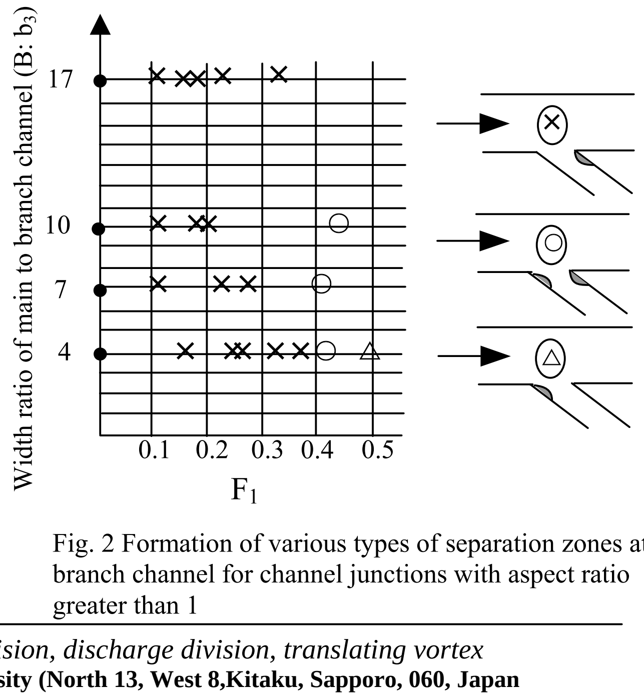

Fig. 2 Formation of various types of separation zones at branch channel for channel junctions with aspect ratio greater than 1

Key words: flow separation, dividing stream line, sediment division, discharge division, translating vortex

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Because of the curve path of the bottom dividing streamline, vortices (Fig. 1) were found to be forming near the branch channel entrance and approaching bottom dividing streamline stroked to the surface of the vortices and followed the path along its surface. Strength and size of the vortices were found to be much with the flow condition having low incoming F_1.

Kudoh [3] with experimental analysis on the junction flow division with free flow condition at the branch channel had reported the division of flow and sediment for the various flow condition. Relationship between the ratios of sediment division to the discharge division at branch to the main channel was found to be around twice in the case of low F_1 and decreased to unity with the increment of F_1.

3) Flow modification for the maximum sediment diversion

In order to have the maximum of the sediment diversion, it is necessary to have the flow modifying structure. There have been various practices of the flow modifying structures e.g. Submerged Vanes, Vortex tube etc. Similarly Oblique weir (Fig. 3) of 45° was also experimented for the purpose of sediment diversion. Different weir heights (3 cm, 5 cm, combination of 5 and 7 cm, 7 cm) were experimented for the different flow condition (Fig. 4,5). For the simulation of the sediment, cylindrical plastic pellet of 3 mm diameter and length with specific gravity 1.2 were used. Similar to the translating vortex developing at the vortex tube, such vortex was also observed along the upstream side of the weir, which caused much of the incoming sediment divert to the branch channel. The effectiveness of the oblique weir was found to be varying with the variation of the weir heights.

4) Conclusion

Various types of separation zones were observed at the branch channel of the open channel junction depending upon the flow condition and the aspect ratio. Due to the curvature shape of the bottom dividing streamline, vortices were observed near the entrance of the downstream wall of the branch channel, which caused the modification of path of approaching bottom dividing streamline while entering in to the branch channel. Ratio of percentage of the sediment entering in to the branch channel to the flow varied approximately from twice to the unity depending upon the Froude Number of the approaching flow. In order to divert the maximum of the incoming sediment with the minimum of the flow, flow modifying structure i.e. Oblique weir (45°) could be used. Translating vortex developed as similar at the Vortex tube caused the incoming sediment diverts towards the branch channel. Effectiveness of the weir was found to be varying with the variation of the weir heights.

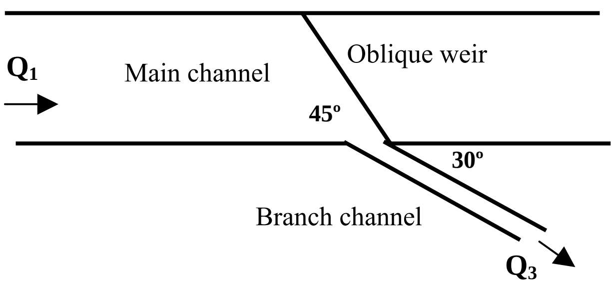

Fig. 3 Schematic diagram of Oblique weir

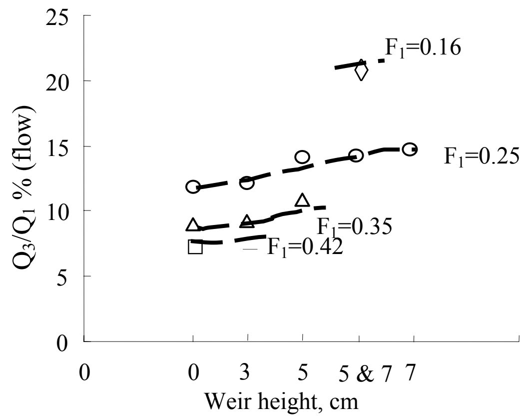

Fig. 4 Variation of flow division with F_1 for weirs of different heights for junction width ratio ($B:b_3$)=12:1

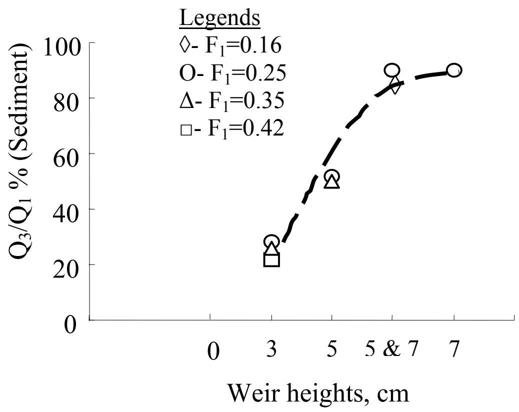

Fig.5 Variation of sediment division with F_1 for weirs of different heights for junction width ratio ($B:b_3$)=12:1

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