HYDRAULIC JUMP AT SLUICE GATE IN NON PRISMATIC INCLINED CHANNEL

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The hydraulic jump is one of the most important hydraulic phenomena used by the engineer to break excessive energy or for mixing purposes. The hydraulic jump is often present in urban and storm open channel flows and in a large number of other open channel flows.

The larger research material about the hydraulic jump is concerning the classical jump, i.e. the jump in an horizontal channel of constant rectangular cross section (prismatic channel). Although, in the recent years some research has been made in non prismatic channels. In the latter case the jump was usually created without a sluice gate, in a region of an abrupt change of the rectangular cross section.

In this paper the jump is created downstream of a -perpendicular to bottom- sluice gate, in a slightly inclined rectangular open channel with inclination angles φ=0.66°-1.90°-3.23°. The results are compared with some previous data by Demetriou et al, 2003, for jumps in horizontal (φ=0°) prismatic and mainly non prismatic open channels. Upstream and downstream of the sluice gate the channel widths are constant for each experiment, but their ratio is changing from experiment to experiment. The abrupt change of widths is realized exactly at the sluice gate location, and three important cases are examined, the jump in expanding inclined channels, in converging inclined channels, and for comparison reasons in prismatic inclined channels.

An equation is initially confirmed by experiments, concerning the jump's conjugate depths' ratio in prismatic inclined channels. This equation is used as a reference equation (and line) for the conjugate depths ratio in inclined non prismatic channels with expanding or converging flows.

For jumps in inclined abruptly expanding channels a number of figures are presented in which the conjugate depths' ratio is compared to the upstream (depth y'_1) Froude number $\left(1.1 \le F'r_1 \le 7.8\right)$ and the inclination angle of the channel. A correction factor K is used for this ratio, and the suitable equation

$$\frac{y'_2}{y'_1} = K \cdot \left\{ 0.5 \cdot \left[\left(1 + 8 \cdot F'r_1{}^2 \right)^{1/2} - 1 \right] \right\} \cdot e^{3.5 \cdot \sin\varphi} \qquad (1)$$

is given, where y'_1, y'_2, are the conjugate depths of the jumps in non prismatic (abruptly expanding) inclined channels ($\varphi \neq 0°$).

K was found from the experiments to be described by the linear equation

$$K = a \cdot \left(b_o / b_1 \right) + b \qquad (2)$$

where a and b are depending on φ (in degrees),

$$\left.\begin{aligned} a &= -0.099\cdot\varphi^3 + 0.467\cdot\varphi^2 - 0.483\cdot\varphi + 0.26 \\ b &= 0.084\cdot\varphi^3 - 0.402\cdot\varphi^2 + 0.434\cdot\varphi + 0.74 \end{aligned}\right\} \qquad (3)$$

and b_o, b_1, are the upstream and downstream widths of the rectangular cross sections. K is always less than 1 for $0.50 \le b_o/b_1 \le 0.88$, while $K \cong 1$ for the limiting case of $b_o/b_1 = 1$.

In general when the widths' ratio is approaching unity the describing lines are turning towards the line of the jump in prismatic inclined channels – especially for larger values of Froude numbers. This is as expected because for small widths' ratios the separation is strong and fully differentiates the jump characteristics in comparison with the jump in prismatic inclined channels, while as the widths' ratio is increasing the flow separation has a reducing effect on the jump.

For jumps in abruptly converging inclined channels $\left(1.1 \le F'r_1 \le 5.6 \text{ and } 1.13 \le b_o/b_1 \le 2.00\right)$ it is concluded through the experiments that their behavior is similar to the jumps' behavior in prismatic inclined channels, because the separation has rather negligible effect on the conjugate depths' ratio.

REFERENCES

Demetriou J., Dimitriou D., 2003, Hydraulic jump at sluice gate in non prismatic channel, XXX IAHR Congress, Vol. II, Theme C, August 2003, Thessaloniki, Greece, pp. 207-212.