SUPER-ELEVATION OF FLOW IN CHANNELS OF NONLINEAR ALIGNMENT

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The presence of curves or bends in alignment is unavoidable in the design of open channels. However, the flow at a bend is quite complicated due to the presence of spiral currents, cross-waves and also the super-elevation of the water surface. The difficulties in the design of channels of nonlinear alignment often arise due to the paucity of information on the reliability of the theoretical formulae available in the literature for the estimation of the super-elevation of flow at bends. In this backdrop, the primary objectives of the present study are: i) to improve our understanding of the flow behaviour at bends, and, ii) to examine the reliability of the theoretical formulae mentioned above, through an experimental investigation of the flow in channels of nonlinear alignment over a range of the relevant dimensionless parameters.

The experimental work was carried out in a 6 m long masonry open channel consisting of a 60^0- bend with a radius of curvature of 0.75 m. The original width and the height of the channel were 310 mm and 350 mm, respectively, whilst the channel slope was 0.02. Subsequently, the width, the height and the slope of the channel were changed to obtain measurements over a wider range of the relevant dimensionless parameters. Further, the velocity measurements were made using a 20 mm diameter propeller meter equipped with a digital counter.

The measurements have been compared with the following semi-empirical formulae that are available to estimate the super-elevation. In these formulae, b is the width of the channel; g is the acceleration due to gravity; r is the radius of curvature of the bend with the subscripts c, i and o denoting centre, inner and outer, respectively; V is the flow velocity; and ΔH is the super-elevation of the flow.

$$\Delta H = \frac{V^2 b}{g r_c} \; .... (1); \qquad \Delta H = 2.30 \frac{V^2}{g} \log \frac{r_o}{r_i} \; .... (2);$$

$$\Delta H = \frac{V_{\max}^2}{g} \left[\frac{20}{3} \frac{r_c}{b} - 16 \frac{r_c^3}{b^3} + \left(\frac{4 r_c^2}{b^2} - 1 \right)^2 \ln \frac{2 r_c + b}{2 r_c - b} \right] ... (3)$$

The results indicate that the measured values of ΔH are closer to equations (1) and (2), whilst equation (3) under-predicts the measurements by about 50%. Therefore, it appears that equations (1) and (2) are more reliable than equation (3) in estimating the super-elevation.

The way in $\Delta H/b$ varies with d/b (d is the water depth) for different values of r_c/b has also been examined, and it appears that the general trend is for $\Delta H/b$ to increase with increase of d/b.

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