FLOW IN S-SHAPED OPEN CHANNEL BENDS

A thesis submitted to the

University of Peradeniya, Sri Lanka

for the degree of

Doctor of Philosophy in the Faculty of Engineering

by

Hewa Henipelle Jeevananda Keerthisena

March 1983

Abstract

The understanding of the physical processes governing the flow in meandering bends is rather poor. This is mainly as a result of a lack of reliable and detailed information on S-shaped open channel bends. Such information is invaluable in interpreting results of distorted scale models of river bends and in improving the design of S-shaped passages used in various duct systems.

In the work reported here three S-bend configurations are investigated over a wide range of flow conditions. Through detailed measurements of the water surface elevations, bed shear stresses and velocity field, the influence of the relevant geometric and flow parameters is analysed and the main features of the flow in open channel S-bends of moderate curvature are explained.

It is found that the reversal of curvature in S-bends leads to significant deformation of the water surface and that the attendant transverse variations of longitudinal pressure gradients have a dominant influence on the redistribution of velocity and of bed shear stress, and on the development and decay of helical flow in S-bends of moderate curvature. Unlike in shallow bends of mild curvature at low Froude numbers, where the flow adjusts freely to the demands of the induced secondary flow, in moderately curved S-bends, at

moderate aspect ratios and Froude numbers, the flow is constrained by the strong longitudinal pressure gradients. At high aspect ratios and Froude numbers the secondary flow is found to be weak and the maximum velocity is located close to the inner wall. The trace of maximum bed shear stress does not follow the trace of maximum velocity and is out of phase with the trace of maximum bed skew angle in the early parts of the bends.

Unlike in the exit region of a single bend leading to a straight channel, the flow in the crossover region of an S-bend is severly deformed and strong lateral nonuniformities are observed. A pair of counterrotating vortices appearing in the second half of an S-bend gives rise to higher skew angles in the central part of the vertical and the streamline pattern near the bed does not fairly represent the helical flow in S-bends.

Simplified mathematical descriptions are presented for the skew angle variation in S-bends, for the deduction of secondary flow profiles from main velocity profiles and for the effects of streamwise acceleration and deceleration of main flow. Using the findings of the present study, several conflicting results in earlier investigations are satisfactorily explained.