The development of a comprehensive computer program for the calculation of flow profiles in open channels

H. B. HUMPIDGE & W. D. MOSS

Mr R. J. Scheurenberg, Balasha-Jalon, Haifa

The presentation by the Authors of a comprehensive computer program for the calculation of water surface profiles is most interesting. The following comments are not intended to detract from the value of an extremely useful paper, but rather to suggest some features which may be added.

59. The requirements of a truly comprehensive program for the computation of flow profiles have been summarized by Eichert.[11] It is suggested that some situations which such a program ought to be able to handle include channels with more than one flow path, e.g. around islands or bridge piers, channels with complex cross sections, e.g. main channel plus flood plain, and the effects of restricted flow at a point which is not strictly a control, e.g. under a bridge. Have the Authors considered any such additions to their program?

60. The Authors have proposed the use of the same differential equation (equation (1)) for the case of spatially varied flow as for constant flow. Do they consider this to be always realistic, even though appreciable secondary currents and additional turbulence may sometimes be present,[12] e.g. in side channel spillways? Can the program deal with the special case of a channel with varying outflow over a side channel spillway where the quantity of outflow is dependent on the depth of water in the main channel?

61. Have any problems been experienced with instability of the Runge-Kutta technique of solution of the equations? If so, would the Authors be prepared to give acceptable limits for the step size or other variables which would ensure a convergent solution.

62. Referring now to § 46, it may be worthwhile in order to save computation time to allow the step size $\Delta\chi$ to be varied. In a long straight reach, for example, the depth of flow may be changing very gradually so that a larger step size may be acceptable than in a reach where the depth is changing more rapidly. It would also be of interest to know which is taken as the positive direction for χ, i.e. χ increasing upstream or downstream, and whether the computation must always be carried out in an upstream direction for subcritical flow and downsteam for supercritical flow. There may be cases where it is desirable to work in the opposite direction, e.g. where water flows into a channel with subcritical floor slope from a reservoir with known water level.

Mr Humpidge and Dr Moss

We would like to thank **Mr Scheurenberg** for his comments. Additions to the program have been considered; its structure lends itself well to modification for particular purposes. A program for calculating flow around islands is, in fact, being developed. The present program is able to handle complex cross sections by representing them as a series of offsets, provided that a single value of roughness is applicable to the whole cross section. Some modification would be needed to deal with cases where a different value was required for different parts of the perimeter such as a main channel and the associated flood plain. Constricted flow at some point not forming a control, where flow remained subcritical throughout, would require the introduction of a

Paper published *Proc. Instn Civ. Engrs*, 1971, **50** (Sept.) 49–64.

procedure to deal with local energy losses at entry or exit; the change in cross-sectional area would not itself present any particular difficulty.

64. The use of equation (1) implies that it is possible to treat the flow in a one-dimensional manner. When this is unacceptable, an equation embodying a fuller treatment, such as that developed by Yen and Wenzel[13] for steady spatially varied flow, would be desirable. Since the program is designed to deal with cases when the rate of flow, although possibly varying along the channel, is known at every point, it cannot deal directly with problems where the flow is dependent on the depths in the channel.

65. No particular problems with instability of the Runge-Kutta technique have been experienced with the examples studied. A step size is read in with the data, but subsequently, for each length between consecutive controls, the computation of the profile is repeated with the step size successively halved until the change in calculated depths between two repetitions is reduced to some acceptably small error. The positive direction of $\Delta \chi$ is normally taken as downstream; profiles will be calculated both upstream and downstream from each control and the dominant profile determined.

66. When water flows from a reservoir with given surface level into a channel with a mild bed slope the rate of flow is not initially known and it would be necessary to establish by an iterative process the rate which would yield a profile such that the specific energy at the head of the channel was equal to the head in the reservoir.

References

11. EICHERT B. S. Survey of programs for water surface profiles. *J. Hydraul. Div. Am. Soc. civ. Engrs*, 1970, **96**, HY2 (Feb.) 547–563.
12. FOX J. A. and GOODWILL I. M. Spatially varied flow in open channels. *Proc. Instn Civ. Engrs*, 1970, **46** (July) 311–325.
13. YEN B. C. and WENZEL H. G. Dynamic equations for steady spatially varied flow. *Jnl Hydraul. Div. Am. Soc. civ. Engrs*, 1970, **96**, HY3 (March) 801–814.