EXPERIMENTAL ASSESSMENT OF A MODIFIED RATIONAL REGIME THEORY

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White, Bettess and Paris (1982) presented a rational regime approach for the design of straight stable trapezoidal channels. However, research has shown that this method under predicts alluvial channel width and over predicts depth, particularly for narrow channels. The method has recently been modified by Eaton and Millar (2004). They applied a bank stability constraint incorporated in the White et al (1982) rational approach. In the study reported here, the results of small-scale laboratory experiments have been used to assess this modification. It was found that although this method can predict the channel dimensions very well, it is weak in predicting sediment transport rate.

In the design and operation of alluvial channels, it is important to determine their geometrical characteristics in dynamic equilibrium. Some of the most recent rational approaches for the design of stable channels solve the combination of a sediment transport equation, a flow resistance relationship, continuity and a fourth relationship which is usually an extremal hypothesis (Thorne, 1998). An extremal hypothesis, based on the maximisation of sediment transport rate, forms the basis of the rational regime approach which White et al (1982) proposed.

Previous work on the White et al (1982) method has shown that equilibrium straight channels can be achieved in the laboratory but the channels are always wider and shallower than predicted (for a limited particle size and flow range) with an equal cross-sectional area.

Eaton and Millar (2004) suggested that, to properly predict alluvial channel width using rational regime methods, it is necessary to incorporate an analysis of bank stability. Therefore, they suggested an additional bank stability constraint to predict the side slope more accurately. To assess this proposed rational method, it was applied to the results of Valentine and Haidera's (2001) experiments on self-formed channels.

The result of this application shows that using a combination of the concept of sediment transport maximisation and bank stability constraint provides a good estimate for the channel dimensions (width and depth). This approach underestimates the sediment concentration. However, as Valentine and Haidera (2001) stated, the discrepancy between predicted and observed values of the White et al (1982) method is due to a difference between predicted and observed channel side slope and sediment concentration. Figure 1 demonstrates the relationship between channel bottom width and sediment concentration. The bank stability constraint modified the side slope prediction, but the sediment transport problem has remained.

It was found that sediment transport theory presently under predicts the observed sediment transport rate. This observation, of course, influences the rational regime prediction which uses this sediment transport formulation. Thus the extremal hypothesis of the maximization of sediment transport rate could not be tested specifically. However, straight regime channel conditions were predicted reasonably well.

This observation suggests the requirement for a new method to predict sediment transport rates. This may involve a new paradigm and subsequently the experimental parameterisation of the approach.

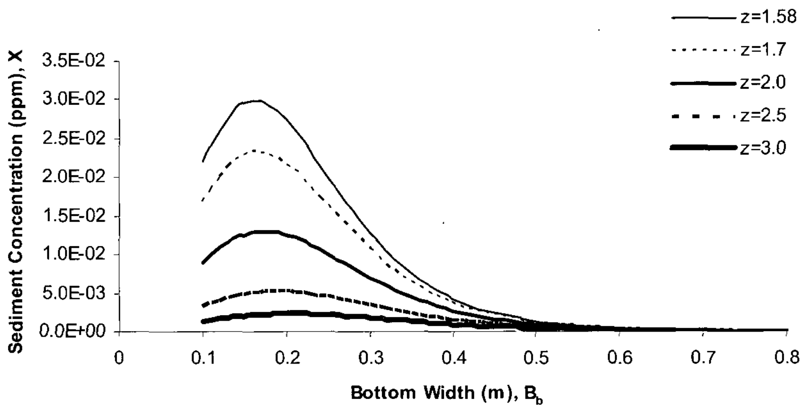

Fig. 1 The variation of sediment concentration with bottom width for different bank slopes, z.

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