THE APPLICATION OF FLOW COMPETENCE EVALUATIONS TO THE ASSESSMENT OF FLOOD-FLOW VELOCITIES AND STRESSES

Paul D. Komar, College of Oceanography, Oregon State University, Corvallis, OR 97331.

The concept of flow competence is generally employed to evaluate the velocities, discharges and bottom stresses of river floods inferred from the size of the largest sediment particles transported (Baker and Ritter, 1975; Costa, 1983). Flow competence has become an important tool for evaluating the hydraulics of exceptional floods on Earth, including those which eroded the Channeled Scabland of eastern Washington (Baker, 1973), and has potential for similar evaluations of the floods which carved the outflow channels on Mars.

For the most part, flow-competence evaluations have been empirical, based on data compiled from a variety of sources including major terrestrial floods caused by natural processes or dam failures. Costa (1983) provides a recent compilation of this data, yielding relationships equivalent to

$$\tau_c = 26.6\ D^{1.21}$$

and

$$u_c = 57\ D^{0.46}$$

respectively for the flood bed stress (τ_c) and velocity (u_c) as a function of the diameter D of the maximum-size gravel or boulders transported (units of the relationships are in the cgs system). Data used in support of these empirical equations include diameters ranging 1 to 500 cm.

Such flow-competence relationships would appear to provide a straight-forward assessment of flood-flow stresses and velocities based on the maximum size of gravel and boulders transported.

However, a re-examination of the data base and comparisons with measurements of selective entrainment and transport of gravel in rivers open to question such evaluations (Komar, in press). It is found that the competence data and empirical relationships trend counter to those obtained for selective entrainment, indicating that the competence evaluations are affected by varying degrees of selective size entrainment as well as by limits to the availability of extreme particle sizes. In many instances the empirical competence equations greatly over-estimate the hydraulics of flood flows, and it is suggested that the better established selective entrainment equations be used instead for competence evaluations as well. For gravels and coarser materials, these can be expressed as the dimensionless relationship

$$\theta_{ti} = 0.045\,(D_i/D_{50})^{-0.7}$$

for the Shields θ_{ti} for the entrainment of a clast of individual diameter D_i from a deposit of mixed sizes having a D_{50} median diameter. The 0.045 and -0.7 coefficients are empirical, based on several data sets such as those of Milhous (1973) and Carling (1973). In the application to flow-competence evaluations, D_i is the maximum size material transported, generally much larger than D_{50}. The relationship indicates that the Shields θ_{ti} for such extreme sizes will be reduced below the 0.045 value given by the standard Shields curve as revised by Miller et al. (1977), a curve which applies to deposits of uniform grain sizes. This results because the larger grains within a deposit of mixed sizes are more exposed to the flow and have smaller pivoting angles, factors which ease their ability to be entrained by the flow. This can be demonstrated through analyses of the forces acting on the grain during entrainment by pivoting, rolling or sliding, an approach which focuses more on the physical processes than the above purely empirical relationships. However, those derived equations require further testing by flume and field measurements before being applied to flow-competence evaluations. Such tests are now underway.

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