Proceedings of the Peradeniya University Research Sessions, Sri Lanka, Vol.11, November 30, 2006

COMPUTATION OF TRANSPORT RATES OF NON-UNIFORM SEDIMENT MIXTURES

K.P.P. PATHIRANA, L.P.J.S. KUMARA, T.B.S. PRIYASHANTHA AND S.B. DARSHANA

Department of Civil Engineering, Faculty of Engineering, University of Peradeniya

The sediment transport mechanism of uniform sediments has been extensively investigated and many formulae are available for computation of transport rates of uniform sediments. Natural river sediments are, however, non-uniform and the transport of such material is more complicated than that of uniform sediments as the movement of one size of sediment is affected by the presence of other sizes in the mixture. Very few studies have been reported in this field and most of the methods proposed for estimating transport rates on sediment mixtures do not produce reliable results and also are not easy to use in real life applications. In this study, a size gradation compensation factor (K_g), which is based on non-dimensional unit stream function, is used to modify the mean diameter of sediment grains in *Engelund and Hansen* formula for estimating transport rates of sediment mixtures. The proposed K_g factor varies according to size gradation of bed material and flow intensity, and hence, the grain size used in the formula will be adjusted as a variable representative size (D_e) to compensate sediment non-uniformity effects in the computation of sediment transport rates for sediment mixtures.

A series of laboratory experiments were carried out in a rectangular, re-circulating, tilting flume to measure bed load transport rates using four sediment mixtures with different mean diameters (D_{50}) and geometric standard deviations (σ_g). The sediments used in the experiments vary from medium sand to fine gravel. For each sediment bed, the transport rates were measured for different discharges and channel slopes. The experimental data collected from other researchers was also used in this study to cover different range of grain sizes. These experimental data were used to test the proposed formulation of variable representative sediment size based on the K_g factor. The application of D_e in *Engelund and Hansen* formula gave much improved results, indicating that the effect of particle gradation on transport rates is eliminated to a certain extent. The standard deviation between the computed and measured transport rates was reduced from 9.7 to 3.8, whereas, the mean normalized error was decreased from 52% to 38%. A better correlation was found between (X_2/K_g) and $\left(h(\sigma_g - 1)/D_{50}\right)$, and hence, the K_g factor can be expressed as;

$$K_g = 12.2 X_2 \left[\frac{h(\sigma_g - 1)}{D_{50}}\right]^{-0.44}, \quad \text{for } \sigma_g > 1, \quad \text{where, } X_2 = \gamma R'_h S / \gamma_s . D_{50}, \; h = \text{flow}$$

depth, $\sigma_g = \sqrt{D_{84}/D_{16}}$, S = channel slope, R'_h = hydraulic radius due to grain roughness, γ_s and γ = the specific weight of sediment and water, respectively. The newly developed equation for K_g factor was verified using the experimental data collected from previous studies and found improved results. This equation is applicable for a wide range of sediment mixtures whose median diameter of sediment varies from coarse to very fine sediments. The use of D_e coupled with the above K_g factor in place of D_{50} in *Engelund and Hansen* formula gives a better prediction of sediment transport rates on non-uniform sediment mixtures with more accuracy.