

tershed in northwest Mississippi should be stable with an average boundary shear stress at channel-forming (2-year) discharge of 0.4 to 0.9 lb/ft².

The value of the Shields constant also varies with bed material size distribution, particularly for paved or armored beds. Andrews (1983) derived a regression relationship that can be expressed as:

$$RS/[(S_s - 1)D_i] < 0.0834 (D_i/D_{50})^{-0.872}$$

When the left side of the above expression equals the right, bed-sediment particles of size D_i are at the threshold of motion. The D_{50} value in the above expression is the median size of subsurface material. Therefore, if $D_{50} = 30$ mm, particles with a diameter of 100 mm will be entrained when the left side of the above equation exceeds 0.029. This equation is for self-formed rivers that have naturally sorted gravel and cobble bed material. The equation holds for values of D_i/D_{50} between 0.3 and 4.2. It should be noted that R and D_i on the left side of the above equation must be expressed in the same units.

Practical Guidance: Allowable Velocity and Shear Stress

Practical guidance for application of allowable velocity and shear stress approaches is provided by the Natural Resources Conservation Service (USDA-NRCS), formerly the U.S. Soil Conservation Service (SCS) (1977), and USACE (1994). See Figure 8.31.

Since form roughness due to sand dunes, vegetation, woody debris, and large geologic features in streams dissipates energy, allowable shear stress for bed stability may be higher than indicated by laboratory flume data or data from uniform channels. It is important to compute cross-sectional average velocities or shear stresses over a range of discharges and for seasonal changes in

the erosion resistance of bank materials, rather than for a single design condition. Frequency and duration of discharges causing erosion are important factors in stability determination. In cobble- or boulder-bed streams, bed movement sometimes occurs only for discharges with return periods of several years.

Computing velocity or shear stress from discharge requires design cross sections, slope, and flow resistance data. If the design channel is not extremely uniform, typical or average conditions for rather short channel reaches should be considered. In channels with bends, variations in shear stress across the section can lead to scour and deposition even when average shear stress values are within allowable limits. The NRCS (formerly SCS) (1977) gives adjustment factors for channel curvature in graphical form that are based on very limited data (see Figure 8.31). Velocity distributions and stage-discharge relations for compound channels are complex (Williams and Julien 1989, Myers and Lyness 1994).

Allowable velocity or shear stress criteria should be applied to in-channel flow for a compound cross section with overbank flow, not cross-sectional average conditions (USACE 1994). Channel flow resistance predictors that allow for changing conditions with changing discharge and stage should be used rather than constant resistance values.

If the existing channel is stable, design channel slope, cross section, and roughness may be adjusted so that the current and proposed systems have matching curves of velocity versus discharge (USACE 1994). This approach, while based on allowable velocity concepts, releases the procedure from published empirical values collected in other rivers that might be intrinsically different from the one in question.