Project: 062065-01
Sheet Number: 1 Of: 1
Calculated by: AS Date: 8-3-10
Checked by: JC Date: 8-12-10

(D_{50}) Airport SAND $\approx$ 1mm

Note: Charts + formulas utilized herein are based on empirically derived data w/fresh water as the medium. It is believed that results w/salt water as the medium would be comparable.

→ Find dimensionless sediment number

$$d_* = \left[\frac{(SG-1)\,g\,d_{50}^3}{\nu^2}\right]^{1/3}$$

$\gamma = 9810\ N/m^3$ (4°C)
SG sand grain = 2.65
$\nu = 1.52E^{-6}\ m^2/s$ (5°C)

$$d_* = \left[\frac{(2.65-1)(9.81\,m/s^2)(1E^{-3}\,m)^3}{(1.52E^{-6}\,m^2/s)^2}\right]^{1/3} = \underline{19.1}\ ✓$$

→ Find critical shear stress

From shields diagram w/ $d_* = 19.1$ $\tau_{*c} = .033$ → transition range

$$\tau_c = (\gamma_s - \gamma)\,d_{50}\,\tau_{*c} = (1.65)(9810\,N/m^3)(1E^{-3}\,m)(.033) = \underline{0.53\,N/m^2}\ ✓$$

→ Find critical velocity

$$V_c = 5.75\left(\sqrt{\frac{\tau_c}{\rho}}\right)\log\left[\frac{12.2\,y_o\,X}{K_s}\right]$$

$K_s = d_{65} = 2\ mm$

$y_o \approx 2\ m$

$$V_c = 5.75\left(\sqrt{\frac{0.53}{1000}}\right)\log\left[\frac{12.2*2*1.2}{2E^{-3}}\right]$$

$$\boxed{= 0.55\ m/s}\ ✓$$

X = velocity correction factor function of K_s/δ

$\delta = 11.6\,\nu/u'_*$ $\quad u'_* = \sqrt{\frac{\tau_c}{\rho}}$

$$\delta = \frac{(11.6)(1.52E-6)}{\sqrt{0.53/1000}} = 7.66E^{-4}$$

$K_s/\delta = 2E^{-3}/7.66E^{-4} = 2.6$

[illegible] Einstien ← correction chart → $X = 1.2$

value represents ocean floor current velocity req'd to induce sand particle movement. Value exceeds estimated Gastineau channel Avg (0.06 m/s) and maximum (0.20 m/s) velocity

P | N | D

1506 West 36th Avenue
Anchorage, Alaska 99503
phone 907.561.1011
fax 907.563.4220

Project: 062065.01
Sheet Number: 1 Of: 1
Calculated by: J. CAMPBELL Date: 8.12.2010
Checked by: Date:

(REF. "GUIDE TO BRIDGE HYDRAULICS", 2nd ED.)

$$V = 1.58\sqrt{9.81}\,(35m)^{0.1}(2.6-1)^{0.5}(0.001m)^{0.4} = \underline{\underline{0.56\ m/sec}}$$

$g = 9.81\ m/s^2$

$y = 115\ ft = 35\ m$

$S = 2.6 \pm$

$D = 1\ mm = 0.001\ m$

ALTERANATE - FROM FIG. 4.13

MOST CONSORVATIVE CASE (SHALLOW DEPTH) = $\underline{\underline{0.7\ m/sec}}$

CONCLUDE:

D_{50} = 1mm Sand not mobile when $V < 0.56\ m/sec$

- layout and geometry of channel control works;
- geometry and alignment of piers and abutments;
- characteristics and stratification of bed and sub-bed materials;
- placement or loss of riprap or other erosion-protection materials;
- natural or man-made changes in patterns of flow or sediment transport;
- proximity to other structures or facilities, or to a river confluence;
- accidents, such as collapse of an upstream dam or nearby structure;
- natural events and catastrophes, such as landslides, volcanic eruptions and earthquakes.

Because of the number of factors and the difficulty in quantifying many of them, engineering judgment is required when estimating potential scour depths and patterns for new bridges and when evaluating experience of scour at existing structures.

Parameters influencing hydraulic erosion of soils

In general terms, the depth and extent of scour at a given location tend to increase with the erosive power of the flow and decrease with the erosional resistance of the exposed soils - with the qualification that in conditions of general bed-material transport, scour may depend on the difference between erosion out of an area and transport into it. Hydraulic conditions for incipient movement of streambed materials are discussed in numerous texts on sediment transport and mobile-boundary hydraulics - for example Graf (1971), Yalin (1972), Raudkivi (1976), Simons and Senturk (1977), Vanoni (1975) and van Rijn (1993).

The erosive power of flowing water on a channel bed in uniform flow is determined primarily by the local hydraulic shear stress or near-boundary velocity, and by turbulent fluctuations in the same. In locations of abrupt geometric changes such as constrictions and bridge piers, macro-turbulent flow phenomena such as eddies, helicoidal flow, rollers, and surges are also important. Average values of velocity and flow depth give only a rough indication of erosive power, but calculations based on more complex parameters are often impracticable. Figure 4.10 illustrates relationships between velocities at different depths in a wide straight stream of uniform depth.

The erosional resistance of a channel bed depends on parameters dependent on soil type, as indicated below:

Cohesionless materials - sand, gravel etc. Erosional resistance depends primarily on grain size, size distribution, and grain density, and to a lesser extent on grain shape, orientation, and packing arrangement. Practical criteria often use grain size and density only. A mixture is often characterized by a single size such as the median (D_{50}), which tends to govern the beginning of erosion in narrowly-graded mixtures. This is an over-simplification for wide gradations, where selective erosion and armoring can occur.

A long-established criterion for beginning of bed movement of cohesionless material is the Shields or Mobility Number, which for the bed of a straight uniform channel can be written in the simplified and dimensionally homogeneous form:

$$M_n = y\,S/[(s-1)D] \qquad \text{Eq.[4.6]}$$

where M_n = Mobility Number, y = depth of flow, S = channel slope, s = relative density of sediment (normally 2.6 or thereabouts) and D = characteristic grainsize. For gravel and larger materials, the critical value of M_n for beginning of movement is often taken as 0.045. For sand, the value can be as low as 0.03 or less under flat-bed conditions. With the bed-forms that are normally present in sandy river beds, however, effective values for beginning of significant movement are generally higher.

Beginning of bed movement can also be expressed in terms of flow velocity, which in many river situations is a more reliable parameter than channel slope. An experimental relationship by Neill (1967) for the bed of a straight uniform channel can be written in the dimensionally homogeneous form:

$$V = 1.58\, g^{0.5}\, y^{0.1}\, (s-1)^{0.5}\, D^{0.4} \qquad \text{Eq.[4.7]}$$

conditions, using fixed-bed analysis or modelling as discussed in Section 4.3. Determine average channel velocities for a range of flows and develop a velocity-discharge curve.

Step 2. Compute the cross-sectional mean velocity through the un-scoured waterway opening under design flood or flow conditions of interest. If this is significantly greater than the corresponding channel velocity at the same flow (Step 1), determine the average level of general scour that will so enlarge the waterway opening as to reduce the mean velocity through it to the same value as in the approach channel.

This simplistic method implies that the exponent m (Method 1) is approximately 1.0. It therefore tends to be more conservative than Method 1.

Method 3: Competent-velocity method

This method can be applied when hydraulic information on the normal channel is inadequate for Methods 1 or 2, and can also serve as a rough check on other methods. The assumption is that general scour will proceed until the mean velocity through the bridge opening is reduced to a value just competent to erode the bed material exposed at the level of scour. If there is substantial bed-material transport in the river, the assumption is admittedly over-conservative. However, it may yet be valid if inflow of bed material to the bridge opening could be interrupted for any reason - for example, gravel mining or an upstream debris jam.

Step 1. Compute the mean velocity through the un-scoured waterway opening under design flood conditions. Using 1-D fixed-bed modelling or otherwise, determine the approximate depth of flow. Determine the median diameter (D_{50}) of the bed material based on a bulk sieve curve or equivalent.

Step 2. For granular materials, compare the computed mean velocity with the competent velocity indicated by Figure 4.13, using the appropriate flow depth and D_{50}. For cohesive materials, compare with Table 4.2. If the computed mean velocity significantly exceeds the competent velocity, general scour should be assumed.

Step 3. Assuming a trapezoidal cross-sectional shape, determine the average general scour level that will make the mean velocity through the opening equal to the competent mean velocity for the grainsize of material encountered at that level, as

Figure 4.13 Suggested competent mean velocities for significant bed movement of granular bed materials, in terms of grain size and depth flow