Stone Fill Stability Analysis: Example Calculations

Permissible Shear Stress, τ_p

$$\tau_p = F_*(\gamma_s - \gamma_w)D_{50}$$

Shield's Parameter, F_*

Particle Reynolds Number	F_*
$R_{ep} \leq 4x10^4$	0.047
$4x10^4 < R_{ep} \leq 2x10^5$	Linear Interpolation
$R_{ep} \geq 2x10^5$	0.10

Particle Reynolds Number, R_{ep}

$$R_{ep} = \frac{U_* D_{50}}{\nu}$$

Shear Velocity, U_*

$$U_* = \sqrt{\tau_b / \rho_w} = \sqrt{\gamma_w y S / \rho_w}$$

$\tau_b - bed\ shear\ stess\ (psf)$

$\tau_p - permissible\ shear\ stress (psf)$

$F_* - Shield's\ parameter$

$U_* - shear\ velocity\ (fps)$

$g - gravitational\ acceleration, (32.2 \frac{ft}{s^2})$

$y - maximum\ flow\ depth\ (ft)$

$S - energy\ or\ channel\ slope\ (\frac{ft}{ft})$

$\nu - kinematic\ viscosity, (1.217x10^{-5}\ ft^2/_s\ @\ 60^0 F)$

$D_{50} - stone\ size\ for\ which\ 50\ percent, by\ weight\ of\ the\ bed\ material\ is\ smaller\ (ft)$

$\gamma_w - specific\ weight\ of\ water\ (62.4 \frac{lb}{ft^3})$

$\gamma_s - specific\ weight\ of\ stone\ (165.36 \frac{lb}{ft^3})$

$\rho_w - density\ of\ weight\ of\ water\ (1.94 \frac{slugs}{ft^3})$

Stone Fill Stability Analysis: Example Calculations

Example 1 – Bed Shear Stress Known

Givens:

Max bed shear was extrapolated from hydraulic model such as SRH-2D, HEC-RAS, or HY-8.

$\tau_b = 3\,psf$

Check:

Will E-Stone Type I be stable?

D50 = 1-ft

$$U_* = \sqrt{\tau_b/\rho_w} = \sqrt{3psf \Big/ 1.94\,\frac{slugs}{ft^3}} = 1.55\,psf$$

$$R_{ep} = \frac{U_* D_{50}}{\nu} = \frac{1.24psf * 1ft}{1.217x10^{-5}\ ft^2/_s} = 127362.37$$

$$F_* = 0.047 + \frac{(127362.37 - 4x10^4)(0.1 - 0.047)}{2x10^5 - 4x10^4}$$

$$F_* = 0.076$$

$$\tau_p = F_*(\gamma_s - \gamma_w)D_{50} = 0.076 * (165.36 - 62.4) * 1$$

$$\tau_p = 7.81\,psf$$

$$\tau_p > \tau_b, Stable$$

Stone Fill Stability Analysis: Example Calculations

Example 2 – Max Flow Depth and Channel Slope Known

<u>Givens:</u>

Max flow depth was determined using Manning's equation, SRH-2D, HEC-RAS, HY-8, etc.

y – 4ft

S – 0.03 ft/ft

<u>Check:</u>

Will E-Stone Type I be stable?

D50 = 1-ft

$$\tau_b = \gamma_w y S = 62.4 * 4 * 0.03 = 7.49\, psf$$

$$U_* = \sqrt{\tau_b / \rho_w} = \sqrt{7.49psf \Big/ 1.94 \frac{slugs}{ft^3}} = 1.96\, psf$$

$$R_{ep} = \frac{U_* D_{50}}{\nu} = \frac{1.96psf * 1ft}{1.217x10^{-5}\ ft^2/_s} = 161432.69$$

$$F_* = 0.047 + \frac{(161432.69 - 4x10^4)(0.1 - 0.047)}{2x10^5 - 4x10^4}$$

$$F_* = 0.087$$

$$\tau_p = F_*(\gamma_s - \gamma_w) D_{50} = 0.087 * (165.36 - 62.4) * 1$$

$$\tau_p = 8.96\, psf$$

$$\tau_p > \tau_b, Stable$$