Project Data Inputs

Enter Project Number:

Enter Upper Station Limit:

Enter Lower Station Limit:

Choose Channel Location: (Right, Center, Left)

Soil Inputs and Shear Strength

Choose USCS Soil Classification Symbol: (GW, GP, GM, GC, SW, SP, SM, SC, MH, ML, CH, CL)

Enter Plasticity Index (PI)*:
*(Enter 0 for nonplastic soils)

Enter soil D75 (inches):

Program determines permissible soil shear stress according to:

<table>
<thead>
<tr>
<th>USCS Symbol</th>
<th>Plasticity Index (-)</th>
<th>Grain Size (in)</th>
<th>Permissible Soil Shear Stress (lb/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW, GP</td>
<td>&lt; 10</td>
<td>0.05 in ≤ D75 ≤ 2 in</td>
<td>( \tau_p = \alpha D_{75} )</td>
</tr>
<tr>
<td>GM</td>
<td>10 ≤ PI ≤ 20</td>
<td></td>
<td>( \tau_p = (0.006 \times PI - 0.03) \frac{lb}{ft^2} )</td>
</tr>
<tr>
<td>GM</td>
<td>20 &lt; PI</td>
<td></td>
<td>( \tau_p = 0.085 \frac{lb}{ft^2} )</td>
</tr>
<tr>
<td>GC</td>
<td>10 ≤ PI ≤ 20</td>
<td></td>
<td>( \tau_p = (0.005 \times PI + 0.05) \frac{lb}{ft^2} )</td>
</tr>
<tr>
<td>GC</td>
<td>20 &lt; PI</td>
<td></td>
<td>( \tau_p = 0.15 \frac{lb}{ft^2} )</td>
</tr>
<tr>
<td>SW, SP</td>
<td>PI &lt; 10</td>
<td>D75 &lt; 0.05 in</td>
<td>( \tau_p = 0.02 \frac{lb}{ft^2} )</td>
</tr>
</tbody>
</table>
Program calculations based on procedures detailed in: HEC-15: Roadside Channels with Flexible Linings

<table>
<thead>
<tr>
<th></th>
<th>PI &lt; 10</th>
<th>0.05 in ≤ D_{75} ≤ 2 in</th>
<th>( \tau_p = \alpha D_{75} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW, SP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM, SC, ML, CL</td>
<td>PI &lt; 10</td>
<td>D_{75} &lt; 0.05 in</td>
<td>( \tau_p = 0.02 \frac{lb}{ft^2} )</td>
</tr>
<tr>
<td>SM, SC, MH, ML, CL</td>
<td>10 &lt; PI ≤ 20</td>
<td></td>
<td>( \tau_p = 0.006 \times PI - 0.03 \frac{lb}{ft^2} )</td>
</tr>
<tr>
<td>SM, SC, MH, ML, CL</td>
<td>20 &lt; PI</td>
<td></td>
<td>( \tau_p = 0.085 \frac{lb}{ft^2} )</td>
</tr>
<tr>
<td>CH</td>
<td>20 &lt; PI</td>
<td></td>
<td>( \tau_p = 0.12 \frac{lb}{ft^2} )</td>
</tr>
</tbody>
</table>

Where \( D_{75} \) = grain size at which 75% of soil is finer (in) and \( \alpha = \) unit conversion constant = 0.4 (CU). Entries outside the range of defined PI or soil grain size should return “undefined”.

**Grass Inputs and Roughness Characteristics**

Choose grass type: (Sod, Mixed, or Bunch)

- **Sod**: spreading grass, such as Bermuda
- **Bunch**: limited spreading, such as Ryegrass
- **Mixed**: combined sod and bunch grasses

Choose Stem Height (ft): (0.25, 0.5, 0.75, 1.0)

Choose Density of Grass Coverage:

(Excellent = 500 stems/ft^2, Good = 300 stems/ft^2, Poor = 100 stems/ft^2)

The grass roughness coefficient is then determined based on the Kouwen resistance equation:

\[
C_n = \alpha C_s^{0.10} h^{0.528}
\]

Where \( C_n \) = grass roughness coefficient

\( C_s \) = density-stiffness coefficient

\( h \) = stem height (ft)

\( \alpha \) = unit conversion 0.237 (CU).
Assuming a density-stiffness coefficient ($C_s$):

\[
= 49 \text{ for excellent grass cover (CU units)}
\]

\[
= 9 \text{ for good grass cover (CU units)}
\]

\[
= 0.73 \text{ for poor grass cover (CU units)}
\]

The grass roughness coefficient will range from 0.1-0.3 for roadside channels, with 0.2 being representative of most conditions.

**Channel Input and Dimensions**

Choose Channel Geometry: (Trapezoidal, Rectangular, Triangular, Parabolic)

Input Left Side Slope (ft/ft): Enter slope as horizontal feet per vertical foot

Input Right Side Slope (ft/ft): Enter slope as horizontal feet per vertical foot

Input Channel Bottom Width (ft)

Input Longitudinal Slope (ft/ft)

Input Initial Estimate of Flow Depth (ft): Enter 1 ft for default

Input Channel Discharge ($ft^3/sec$)

**Calculated Channel Parameters**

Clicking “Calculate Channel Parameters & Lining Acceptability” starts the program calculations to determine permissible shear stress on the vegetation.

Based on the initial depth estimate, the channel geometric parameters are calculated (area $A$, wetted perimeter, top width, and hydraulic radius ($R$)). Applied shear stress is calculated according to:

\[
\tau_o = \gamma RS_o
\]
where \( \gamma \) = unit weight of water (62.4 lb/ft\(^3\)) and \( S_o \) = longitudinal slope.

Manning’s roughness is determined according to:

\[
n = \alpha C_n \tau_o^{-0.4}
\]

Where \( n \) = Manning’s roughness, \( \tau_o \) = mean boundary shear stress (lbft\(^2\)), \( \alpha \) = unit conversion = 0.213 for (CU).

Next, the flowrate is determined according to:

\[
Q = \frac{\alpha}{n} AR^{2/3} S^{1/2}
\]

where \( \alpha \) = unit conversion = 1.49 (CU) and \( n \) = Manning’s coefficient.

The program iterates until the design flowrate = the calculated flowrate, then the maximum shear stress on the channel bottom is determined according to:

\[
\tau_d = \gamma d S_o
\]

where \( d \) = depth of flow.

The permissible vegetation/soil shear stress is then determined according to:

\[
\tau_p = \frac{\tau_{p, soil}}{(1 - C_f)} \left( \frac{n}{n_s} \right)^2
\]

Where

\( \tau_p \) = permissible shear stress on vegetative lining (lb/ft\(^2\))

\( \tau_{p, soil} \) = permissible soil shear stress (lb/ft\(^2\))

\( C_f \) = grass cover factor:

- Sod: Excellent = 0.98; Good = 0.90; Poor = 0.75
- Mixed: Excellent = 0.82; Good = 0.75; Poor = 0.62
- Bunch: Excellent = 0.55; Good = 0.50; Poor = 0.41

\( n_s \) = soil grain roughness
Program calculations based on procedures detailed in: HEC-15: Roadside Channels with Flexible Linings

\[ n_s = 0.016, \text{ when } D_{75} < 0.05 \text{ in (1.3 mm)}, \]

Otherwise: \[ n_s = \alpha (D_{75})^{1/6} \]

Where \( D_{75} = \) grain size at which 75\% of soil is finer, mm (in)

\( n = \) Manning’s roughness coefficient

If the permissible vegetation/soil shear stress is greater than the maximum shear stress on the channel bottom, the grass only is an acceptable lining. If not, the required category of TRM protection is reported.

**Riprap calculations**

Clicking “Calculate Riprap” results in the following:

For riprap sizing, the area of flow, wetted perimeter, top width, hydraulic radius, discharge, velocity, and depth of flow are calculated using the same equations as previous. However, Manning’s roughness coefficient for riprap is determined according to:

\[ n = \frac{0.262 \cdot d_a^{1/6}}{2.25 + 5.23 \log \left( \frac{d_a}{D_{50}} \right)} \]

where \( n = \) Manning’s roughness, \( D_{50} = \) median riprap size (ft), and \( d_a = \) average flow depth in channel (ft).

Riprap can then be sized according to (HEC15, 2005):

\[ D_{50} = \frac{SF \cdot d \cdot S_o}{F_*(SG - 1)} \]

Where \( SF = \) safety factor, \( d = \) maximum channel depth, \( S_o = \) channel slope, \( F_* = \) Shields parameter, and \( SG = \) specific gravity of rock.
The Shields parameter varies as a function of Reynolds number, which is determined according to:

$$ R_e = \frac{V_* D_{s0}}{\nu} \quad \text{where:} \quad V_* = \sqrt{g d_a S} $$

where $V_*$ = shear velocity, $S$=slope, and $\nu$ = kinematic viscosity.

The resulting Shields parameter and safety factor are given as follows (HEC15, 2005):

<table>
<thead>
<tr>
<th>Reynolds Number</th>
<th>$F_*$</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 4 \times 10^4$</td>
<td>0.047</td>
<td>1.0</td>
</tr>
<tr>
<td>$4 \times 10^4 &lt; Re &lt; 2 \times 10^5$</td>
<td>Linear interpolation</td>
<td>Linear interpolation</td>
</tr>
<tr>
<td>$\geq 2 \times 10^5$</td>
<td>0.15</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Submit Data

Once the calculations have been completed, click “Submit Data”. You will receive a data submitted message, and can then return to enter the next section of the project.

Download Data

To retrieve stored data, click the link titled Generate Report.

Enter the Project Number, then click submit. (Note: if you only want a specific station for the project number, enter the project number and the upper and lower station limits).

Click “Download Report”, and the project information will download as a .csv file that can be opened in Excel.