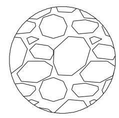
Riprap

Plan Symbol



Description

Riprap is a permanent, erosion-resistant channel lining aggregate consisting of large, loose, angular stone with a filter fabric or granular underlining. The purpose of riprap is to:

- Protect the soil from the erosive force of concentrated runoff
- Slow runoff velocities while enhancing the potential for infiltration

The filter fabric or granular underlining prevents undermining of the riprap layer by the migration of soil particles under seepage forces through the riprap.

When and Where to Use It

The preferred method of slope and channel protection is the use of vegetation. If vegetation can not withstand the design flows, ECBs and TRMs are the preferred and suggested method of protection. When conditions are too severe for vegetation and TRMs, riprap may be used for erosion control and protection. Riprap is used, as appropriate, at storm drain outlets, on channel banks and/or bottoms, drop structures, at the toe of slopes, and in transitions from concrete channels to vegetated channels. Riprap sizes are designed by the diameter or by the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stones should be angular instead of spherical.

Installation

Place a lining of geotextile filter fabric or granular filter material between the riprap and the underlying soil surface to prevent soil movement into or through the riprap.

Inspection and Maintenance

- Once a riprap installation has been completed, it should require very little maintenance.
- It should, however, be inspected periodically to determine if high flows have caused scour beneath the riprap and filter fabric or dislodged any of the stone.
- Care must be taken to properly control sediment-laden construction runoff that may drain to the point of the new installation. If repairs are needed, they should be performed immediately.

Riprap Design Criteria

Riprap at Outlets

Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structure are given in the Outlet Protection section of this Manual.

Riprap for Channel Stabilization

Design of erosion protection within the channel can be accomplished using the FHWA Tangent Flow Method presented below. This method is applicable to both straight and curved channel sections where flows are tangent to channel bank. The Tangent Flow Method determines a stable rock size for straight and curved channel sections using known shape, flow depth, and channel slope dimensions. A stone size is chosen for the maximum depth of flow. If the sides of the channel are steeper than 3H:1V, the stone size must be modified. The final design size will be stable on both the sides and bottom of the channel.

Straight Channel Sections

1. Refer to the graph shown in Figures RR1 with the maximum flow depth (**d** in feet) and channel slope (ft/ft). Select the point where the maximum flow depth and channel slope intersect. Choose the $\mathbf{d_{50initial}}$ stone size based upon the location of the point of intersection.

2. This completes the design procedure for channels with side slopes 3H:1V and flatter. If the channel side slopes are steeper than 3H:1V, continue with step 3.

3. Refer to the graph shown in Figure RR2 with the side slope (**Z** in H:V) and the base width **(B)** to maximum depth **(d)** ratio **(B/d)**. Where the two lines intersect, move horizontally left to read $\mathbf{K_1}$.

4. Determine from the graph in Figure RR3 the angle of repose for the $\mathbf{d_{50initial}}$ stone size and the channel side slope **Z**. (Use an angle of 42° for $\mathbf{d_{50initial}}$ >10-inches. Do not use riprap on slopes steeper than the angle of repose for the stone size.)

5. Refer to the graph shown in Figure RR4 with the side slope **(Z)** of the channel and the angle of repose for the $\mathbf{d_{50initial}}$ stone size. Where the two lines intersect, move vertically down to read $\mathbf{K_2}$.

6. Compute $\mathbf{d_{50initial} \times K_1/K_2 = d_{50design}}$ to determine the correct size stone for the bottom and side slopes of straight sections of channel.

Curved Channel Sections

1. Refer to steps 1-6 under Straight Channel Sections
2. Determine the radius of the curved section $\mathbf{(R_O)}$ in feet.
3. Calculate the top width of the riprap at the design water surface $\mathbf{(B_S)}$ in feet

B_S	=	$B_O + 2(Z*D)$
B_O	=	Bottom width of channel (feet)
Z	=	Channel sides slopes defined as ZH:1V
D	=	Depth of riprap (feet)

4. Calculate the Ratio $\mathbf{B_S / R_O}$
5. Knowing the value of the $\mathbf{B_S/R_O}$ ratio from step 4, use the graph in Figure RR5 and read the corresponding value of $\mathbf{K_3}$.
6. Compute $\mathbf{(d_{50design} \times K_3) = d_{50curve}}$ to determine the correct size stone for the bottom and side slopes of curved channel sections.

Straight Channel Design Example

Given: Trapezoidal channel depth (D) 3-feet, bottom width (B_o) 8-feet, side slopes (Z) 2H:1V, and a 2 percent slope.

Find: A stable riprap size for the bottom and side slopes of the channel.

Solution:

1. From Figure RR1, for a 3-foot-deep channel over a 2 percent grade,
   Read $d_{50initial}$ = 0.75-feet or 9-inches.

2. Since the side slopes are steeper than 3H:1V, continue with step 3
   **If side slopes were less than 3H:1V, the process would be complete.

3. From Figure RR2, $B_O/d = 8/3 = 2.67$, Side slopes Z = 2,
   Read $K_1 = 0.82$.

4. From Figure RR3, for $d_{50initial}$ = 9-inches,
   Read Angle of Repose = 41

5. From Figure RR4, side slopes Z = 2, and Angle of Repose = 41 ,
   Read $K_2 = 0.73$.

6. Stable Riprap = $d_{50design} \times (K_1/K_2) = 0.75 \times (0.82/0.73) = 0.84$-feet or 10-inches

Curved Channel Design Example

Given: The preceding straight channel example has a curved section with a radius of 50-feet.

Find: A stable riprap size for the bottom and side slopes of the curved channel section.

Solution:

1. Stable Riprap = $d_{50design}$ 10-inches from straight channel calculations.

2. R_O = 50-feet.

3. Calculate Channel Top Width of Water Surface
   $B_S = B_O + 2(Z*D) = 8 + 2(2*3) = 20$-feet.

4. Calculate the Ratio B_S / R_O
   $= 20/50 = 0.40$

5. From Figure RR5, for $B_S / R_O = 0.40$
   Read $K_3 = 1.1$

6. $d_{50curve} = d_{50design} \times K_3 = (0.84\text{-ft.} \times 1.1) = 0.92$-feet or 11-inches.

Riprap Lined Channel

Preventive Measures and Troubleshooting Guide

Field Condition	Common Solutions
High flows causing scour beneath riprap or filter fabric dislodging the stone.	Replace filter fabric and rearrange stone appropriately.
Riprap blocks channel, causing erosion along edges.	Make sure excavation is deep enough, rearrange riprap appropriately.
Piping or slumping occurs.	Make sure filter fabric was installed and make sure it isn't damaged.
Stones have moved and erosion of foundation has occurred.	Make sure riprap is properly graded.
Undercut riprap slope and slumping occurring.	Check to be sure that foundation toe is properly reinforced.
Stone displacement occurring.	Make sure fill slopes have been properly compacted, remove debris and make needed repairs.