

4.2-g RIPRAP

Alternative Names: Rock Slope Protection

DESCRIPTION

Rock riprap is the controlled placement of large angular rock (stone, cobbles, boulders) over soil to protect and stabilize the soil surface from erosion. Riprap is commonly used to stabilize over-steepened slopes. Riprap can also be used to protect culvert inlets and outlets, stream banks, drainage channels (as a lining), or other areas subject to erosion by stormwater runoff.



APPLICABILITY

- Cut and fill slopes typically steeper than 3:1 (run to rise), or any sloped area prone to erosion that may be difficult to revegetate.
- Along stream banks or within drainage channels as a stable lining resistant to scour.
- Within small drainage channels where infiltration is desirable but the potential for scour is too great for application of vegetative stabilization or geotextile linings.
- In the shorezone, or other areas subject to wave action.
- Energy dissipation for pipe outlets and inlets to prevent scour and undercutting.

BMP DESIGN APPROACH

- Pollutant Source Control
- Hydrologic Source Control
- Stormwater Treatment

SCALE OF APPLICATION

- All SFR and MFR < 1 acre
- MFR 1-5 Acre and CICU < 5 acres
- MFR and CICU > 5 acres and all WQIPs

BMP TYPE

- Temporary
- Permanent

Advantages

- Versatile and applicable for many applications.
- When installed correctly, riprap can be highly effective at hindering erosion and stabilizing soils.
- When used to line small drainage channels, riprap provides a stable channel structure and reduces stormwater velocities.
- Allows for seeding or inter-planting between rocks.

Disadvantages

- Displacement of riprap may occur:
 - On steep slopes typically greater than 1.5:1 (run to rise).
 - If riprap is too small.
 - If the toe is not stabilized properly or if riprap is not correctly installed.
- Displacement occurring adjacent to roadsides may present a safety hazard.
- Installation without successful revegetation results in a barren appearance that is typically considered a poor aesthetic.
- The cost of hauling rock can make riprap a relatively expensive compared to other stabilization techniques.

DESIGN CONSIDERATIONS

- Typically applied when revegetation success is unlikely for slopes steeper than 3:1 (run to rise). Displacement and constructability issues are concerns for riprap on slopes typically steeper than 1.5:1.
- When designing a channel lining with riprap, ensure that design calculations consider potential reductions in channel capacity caused by the riprap.
- Use durable angular rock and avoid rounded stones or cobbles.
- Ensure that the color of Riprap is compatible with the surroundings. Select colors from the Munsell® colors set forth in Appendix G, TRPA Approved Range of Earthtone Colors, of the TRPA Design Review Guidelines.
- For complicated applications, consult with a licensed professional civil engineer to design riprap based on drainage computations, slope conditions, soil conditions, and other constructability issues. For simple applications the following design guidelines may be followed:
 - Riprap should be sound, dense, and durable angular rock with a minimum specific gravity of 2.6.
 - Riprap ranges in size from 9 inches to 18 inches. Smaller size rock is typically not appropriate.

INSTALLATION CONSIDERATIONS

- If desired, broadcast seed before rock placement. Consider provisions to control weed establishment in riprap prior to installation.
 - Remove ground cover, litter, and smaller woody vegetation. Retain larger trees and shrubs where desirable, around which rock should be placed by hand.
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- Compact subgrade to prevent slumping or undercutting where feasible. Place riprap by hand or using mechanized equipment.
- A gravel filter layer or geotextile filter fabric layer is typically placed prior to riprap placement to maintain separation between the rock material and the underlying soil, which prevents soil loss and provides a bed to allow easier placement of rock.
 - Gravel filter layer: A layer of well-compacted gravel provides a smooth bed to allow easier placement of riprap. A few inches of gravel is typically sufficient as a filter layer.
 - Geotextile filter fabric layer: A filter fabric layer is typically easier to install on steeper slopes relative to a gravel filter layer, but it is more difficult to bed the rock relative to a gravel filter layer. Place the filter fabric so that it is not stretched and conforms closely to the subgrade. Secure filter fabric by using anchor trenches, stakes, staples, or other means necessary according to the manufacturer's recommendations. Bury the upper portion of the filter fabric and the toe of the filter fabric to prevent unraveling.
- Typically, the riprap layer should be at least twice as thick as the maximum rock diameter used. Rocks should be securely bedded in contact to one another, with larger rocks uniformly distributed and smaller rocks filling the voids.
- Ensure that the slope above the riprap is stable to prevent sloughing and failure of the slope into the riprap section.

INSPECTION AND MAINTENANCE

Refer to Riprap Inspection and Maintenance Table for inspection and maintenance protocols.

EFFECTIVENESS CONSIDERATIONS

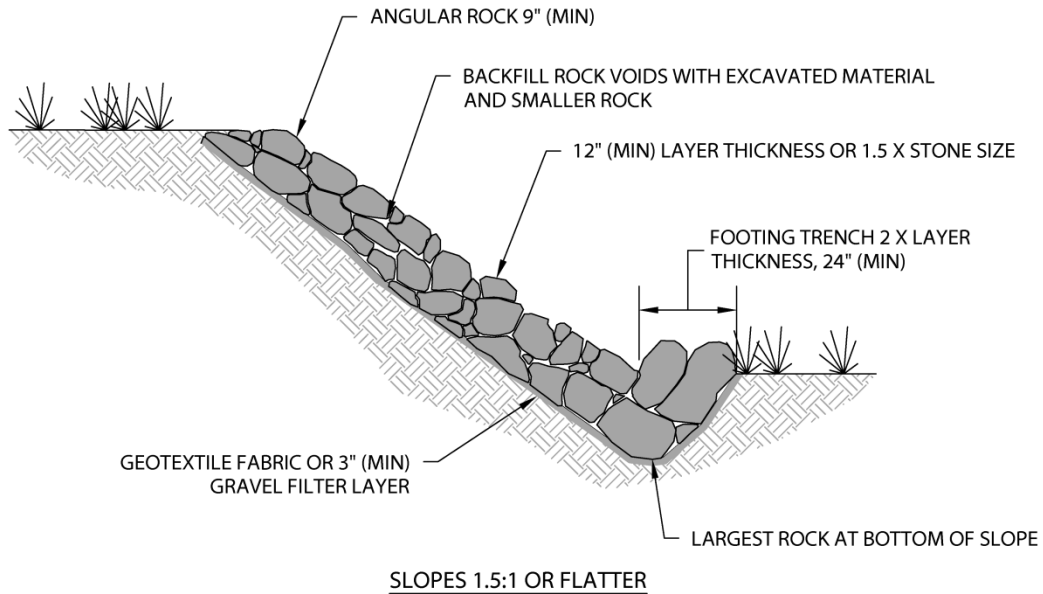
Rock riprap can be highly effective at preventing soil erosion from steep slopes. When properly installed, rock riprap can be effective for long periods of time while requiring minimal maintenance. Riprap is more broadly accepted from an aesthetic standpoint when vegetation is established throughout the riprap.

Riprap Inspection and Maintenance Table

INSPECTION AND MAINTENANCE ACTIVITIES	SUGGESTED FREQUENCY	INSPECTION EQUIPMENT	MAINTENANCE EQUIPMENT
Inspect for trash and unwanted debris. <ul style="list-style-type: none"> ▪ Remove trash and unwanted debris from the area. 	Monthly (April–Oct)		Trash bag
Inspect for soil erosion and accumulation, especially at the top and bottom of the slope. <ul style="list-style-type: none"> ▪ Remove accumulated sediment with shovel, backhoe, or vactor truck. ▪ Dispose of sediment at a TRPA approved stable on-site location or out of the Lake Tahoe Region. ▪ Stabilize eroded and undercut areas. ▪ If upslope soil is overtopping treatment repeatedly, extend rock to hinge of slope. 	Monthly (April–Oct)		Shovel, Backhoe, or Vactor Truck Additional Rock
Inspect for invasive weeds ¹¹ . <ul style="list-style-type: none"> ▪ Remove invasive weeds monthly during the first two growing seasons. Thereafter, weed annually, or as needed. 	Monthly during first growing season and annually thereafter	Invasive Weeds Inspector	Tools as needed to control infestation
Inspect for animal burrows, holes and mounds. <ul style="list-style-type: none"> ▪ If burrows are causing erosion or compromising structural integrity, backfill firmly. It may be necessary to chink void spaces with smaller rock. 	Annually in fall after vegetation trimming		Tools as needed to repair
Inspect for dislodged or unstable rock which could pose safety hazards. <ul style="list-style-type: none"> ▪ Repair dislodged or unstable rock. 	Annually in spring		Additional Rock
Inspect site for unusual or unsafe conditions (snowplow damage, structural damage, dumping, tree establishment, etc.). <ul style="list-style-type: none"> ▪ Repair or replace rock as necessary. 	Annually in spring		Tools as needed
Monitor ongoing effectiveness and determine whether another BMP type or additional rock could improve long-term effectiveness and improve benefits to costs versus the existing rock slope protection. <ul style="list-style-type: none"> ▪ Analyze Inspection and Maintenance Log for trends and recurring issues. ▪ Prepare a plan that more effectively addresses slope stabilization, reduces long term maintenance costs, and improves overall effectiveness and safety of the BMP. 	Every 5 years	Qualified Inspector or Consultant	Qualified Inspector or Consultant

¹¹ Lake Tahoe Basin Weed Coordinating Group. <http://www.tahoeinvasiveweeds.org/>.

Riprap Slope Protection Figure



NOTES:

1. RIPRAP SHALL BE HARD, DURABLE, ANGULAR ROCK WITH A MINIMUM SPECIFIC GRAVITY OF 2.6.
2. ROCKS SHALL BE PLACED TO FORM A STABLE STRUCTURE WITH A MINIMUM OF VOIDS AND EACH ROCK SHOULD HAVE A 3 POINT BEARING CONTACT WITH ROCKS BELOW.
3. IF A GRAVEL FILTER LAYER IS SUBSTITUTED FOR GEOTEXTILE, THEN THE MATERIAL SHALL BE A MIXTURE OF SAND AND GRAVEL, CONSISTING OF 1 1/2" IN SIZE OR LESS.
4. RIPRAP SLOPE PROTECTION SHALL BE INDIVIDUALLY DESIGNED BY A CIVIL ENGINEER FOR SLOPES GREATER THAN 6 FEET HIGHER, WHERE SEEPAGE OR OTHER INDICATIONS OF GENERAL SLOPE INSTABILITY ARE PRESENT, OR WHERE STRUCTURES ARE AFFECTED.
5. FOR NON-PERMITTED PROJECTS, REVEGETATE ADJACENT AREAS IN ACCORDANCE WITH THE TRPA BMP HANDBOOK. FOR PERMITTED PROJECTS, REVEGETATE ADJACENT AREAS TO SPECIFICATIONS OF REVEGETATION PLAN.
6. RETAIN LARGER TREES AND SHRUBS WHERE FEASIBLE.
7. APPLY GEOTEXTILE FABRIC BEFORE INSTALLING ROCKS ON SLOPES WHERE CONCENTRATED FLOW IS EXPECTED OR SEEPAGE WILL OCCUR. OTHERWISE, CONSTRUCT WITHOUT GEOTEXTILE FABRIC OR CONSULT A CIVIL ENGINEER FOR SITE SPECIFIC REQUIREMENTS.

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