

## RIPRAP

From *Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas*  
<http://www.mass.gov/dep/water/laws/policies.htm#storm>

### Definition:

A permanent, erosion-resistant ground cover of large, loose, angular stone.



### Purpose

- To protect slopes, streambanks, channels, or areas subject to erosion by wave action.
- Rock riprap protects soil from erosion due to concentrated runoff. It is used to stabilize slopes that are unstable due to seepage. It is also used to slow the velocity of concentrated runoff which in turn increases the potential for infiltration.

### Where Practice Applies

- Cut or fill slopes subject to seepage or weathering, particularly where conditions prohibit establishment of vegetation.
- Channel side slopes and bottom.
- Inlets and outlets for culverts, bridges, slope drains, grade stabilization structures, and storm drains; where the velocity of flow from these structures exceeds the capacity of the downstream area to resist erosion.
- Stream banks and stream grades.
- Shorelines subject to wave action.

### Advantages

- Riprap offers an easy-to-use method for decreasing water velocity and protecting slopes from erosion. It is simple to install and maintain.
- Riprap provides some water quality benefits by increasing roughness and decreasing the velocity of the flow, inducing settling.

## Disadvantages/Problems

- Riprap is more expensive than vegetated slopes.
- There can be increased scour at the toe and ends of the riprap.
- Riprap does not provide the habitat enhancement that vegetative practices do.

## Planning Considerations

- Well-graded riprap forms a dense, flexible, self-healing cover that will adapt well to uneven surfaces.
- Care must be exercised in the design so that stones are of good quality, sized correctly, and placed to proper thickness.
- Riprap should be placed on a proper filter material of sand, gravel, or fabric to prevent soil from “piping” through the stone.
- Contact the local Conservation Commission regarding any stream crossing or other work conducted in a wetland resource area. The Massachusetts Wetland Protection Act requires that the proponent file a “Determination of Applicability” or “Notice of Intent.”
- Rock riprap is used where erosion potential is often high. The rock should be placed as soon as possible after disturbing the site, before additional water is concentrated into the drainage system. Properly sized bedding or geotextile fabric is needed to prevent erosion or undermining of the natural underlying material.
- Riprap is classified as either graded or uniform. Graded riprap contains a mixture of stones which vary in size. A sample of uniform riprap would contain stones which are all fairly close in size. For most applications, graded riprap is preferred to uniform riprap. Graded riprap forms a flexible self-healing cover, while uniform riprap is more rigid and cannot withstand movement of the stones. Graded riprap is cheaper to install, requiring only that the stones be dumped so that they remain in a well-graded mass.
- Hand or mechanical placement of individual stones is limited to that necessary to achieve the proper thickness and line. Uniform riprap requires placement in a more or less uniform pattern, requiring more hand or mechanical labor.

## Design Recommendations

As graded riprap consists of a variety of stone sizes, a method is needed to specify the size range of the mixture of stone. This is done by specifying a diameter of stone in mixture for which some percentage, by weight, will be smaller. For example, d 85 refers to a mixture of stones in which 85 percent of the stone by weight would be smaller than the diameter specified. Most designs are based on "d." The design, therefore, is based on the median size of stone in the mixture. A well graded mixture of rock sizes should be used for riprap rather than rocks of a uniform size. Rock riprap sizes are specified by either weight or diameter. Stone should be hard, angular, weather-resistant; specific gravity at least 2.5.

**Gradation:** well-graded stone, 50% by weight larger than the specified "150" The largest stones should not exceed 1.5 times the "d50" specified. Stones should be shaped so that the least dimension of the stone fragment is not less than one-third of the greatest dimension of the fragment. Flat rocks should not be used for riprap.

**Filter:** heavy-duty filter fabric or aggregate layer should be used under all permanent riprap.

**Thickness:** 1.5 times the maximum stone diameter, minimum, or as specified in the plan.

## Construction Recommendations

- Subgrade for filter material, geotextile fabric or riprap should be cleared and grubbed to remove all roots, vegetation, and debris and prepared to the lines and grades shown on the plans.
- Excavate deep enough for both filter and riprap. Compact any fill material to the density of surrounding undisturbed soil.
- Excavate a keyway in stable material at base of slope to reinforce the toe. Keyway depth should be 1.5 times the design thickness of riprap and should extend a horizontal distance equal to the design thickness.
- Rock and/or gravel used for filter and riprap shall conform to the specified gradation.
- Voids in the rock riprap should be filled with spalls and smaller rocks.

## Filter

Install synthetic filter fabric or a sand/gravel filter on subgrade.

### Synthetic filter fabric

Place filter fabric on a smooth foundation. Overlap edges at least 12 inches, with anchor pins spaced every 3 ft along overlap. For large stones, a 4-inch layer of sand may be needed to protect filtercloth.

Geotextile fabrics should be protected from puncture or tearing during placement of the rock riprap by placing a cushion of sand and gravel over the fabric. Damaged areas in the fabric should be repaired by placing a piece of fabric over the damaged area or by complete replacement of the fabric. All overlaps required for repairs or joining two pieces of fabric should be a minimum of 12 inches.

### **Sand/gravel filter**

Spread well-graded aggregate in a uniform layer to the required thickness (6 inches minimum). If two or more layers are specified, place the layer of smaller stones first and avoid mixing the layers.

### **Stone Placement**

- Place riprap immediately after installing filter.
- Install riprap to full thickness in one operation. Do not dump through chutes or use any method that causes segregation of stone sizes. Avoid dislodging or damaging underlying filter material when placing stone.
- If fabric is damaged, remove riprap and repair fabric by adding another layer, overlapping the damaged area by 12 inches.
- Place smaller stones in voids to form a dense, uniform, well-graded mass. Selective loading at the quarry and some hand placement may be necessary to obtain an even distribution of stone sizes.
- Blend the stone surface smoothly with the surrounding area, allowing no protrusions or overfall.
- Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance.
- Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

## Common Trouble Points

- **Excavation not deep enough:** Riprap blocks channel, resulting in erosion along edges.
- **Slope too steep:** Results in stone displacement. Do not use riprap as a retaining wall.
- **Foundation not properly smoothed for filter placement:** Results in damage to filter.
- **Filter omitted or damaged:** Results in piping or slumping.
- **Riprap not properly graded:** Results in stone movement and erosion of foundation.
- **Foundation toe not properly reinforced:** Results in undercut riprap slope or slumping.
- **Fill slopes not properly compacted before placing riprap:** Results in stone displacement.

## Maintenance

- Riprap should be checked at least annually and after every major storm for displaced stones, slumping, and erosion at edges, especially downstream or downslope. If the riprap has been damaged, it should be repaired immediately before further damage can take place.
- Woody vegetation should be removed from the rock riprap annually because tree roots will eventually dislodge the riprap.
- If the riprap is on a channel bank, the stream should be kept clear of obstructions such as fallen trees, debris, and sediment bars that may change flow patterns, which could damage or displace the riprap.

## References

Massachusetts Department of Environmental Protection, Office of Watershed Management, Nonpoint Source Program, Massachusetts **Nonpoint Source Management Manual**, Boston, Massachusetts, June, 1993.

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