Riprap

Riprap can be used to stabilize drainageways and outlets to prevent erosion

Description
Riprap is a permanent, erosion-resistant layer made of stones. It is intended to protect soil from erosion in areas of concentrated runoff. Riprap may also be used to stabilize slopes that are unstable because of seepage problems.

Applicability
Riprap can be used to stabilize cut-and-fill slopes; channel side slopes and bottoms; inlets and outlets for culverts, bridges, slope drains, grade stabilization structures, and storm drains; and streambanks and grades.

Siting and Design Considerations
Riprap may be unstable on very steep slopes, especially when rounded rock is used. For slopes steeper than 2:1, consider using materials other than riprap for erosion protection. If riprap is being planned for the bottom of a permanently flowing channel, the bottom can be modified to enhance fish habitat. This can be done by constructing riffles and pools which simulate natural conditions. These riffles promote aeration and the pools provide deep waters for habitats.
The following are some design recommendations for riprap installation, (Smolen et al., 1988):

- *Gradation*. A well-graded mixture of rock sizes should be used instead of one uniform size.
- *Quality of stone*. Riprap must be durable so that freeze/thaw cycles do not decompose it in a short time; most igneous stones such as granite have suitable durability.
- *Riprap depth*. The thickness of riprap layers should be at least 2 times the maximum stone diameter.
- *Filter material*. Filter material is usually required between riprap and the underlying soil surface to prevent soil from moving through the riprap; a filter cloth material or a layer of gravel is usually used for the filter.
    - *Leaching Protection*. Leaching can be controlled by installing a riprap gradation small enough to act as a filter against the channel base material, or a protective filter can be installed between the riprap and the base material.
    - *Riprap Limits*. The riprap should extend for the maximum flow depth, or to a point where vegetation will be satisfactory to control erosion.
    - *Curves*. Riprap should extend to five times the bottom width upstream and downstream of the beginning and ending of the curve as well as the entire curved section.
    - *Riprap Size*. The size of riprap to be installed depends on site-specific conditions.

Limitations
Riprap is limited by steepness of slope, because slopes greater than 2:1 have potential riprap loss due to erosion and sliding. When working within flowing streams, measures should be taken to prevent excessive turbidity and erosion during construction. Bypassing base flows or temporarily blocking base flows are two possible methods.

Effectiveness
When properly designed and installed, riprap can prevent virtually all erosion from the protected area.

Maintenance Considerations
Riprap should be inspected annually and after major storms. If riprap has been damaged, repairs should be made promptly to prevent a progressive failure. If repairs are needed repeatedly at one location, the site should be evaluated to determine if the original design conditions have changed. Channel obstructions such as trees and sediment bars can change flow patterns and cause erosive forces that may damage riprap. Control of weed and brush growth may be needed in some locations.

Cost Considerations
The cost of riprap varies depending on location and the type of material selected. A cost of $35 to $50 per square yard of nongrouted riprap has been reported, while grouted riprap ranges from $45 to $60 per square yard (1993 dollars; Mayo et al., 1993). Alternatives to riprap channel lining include grass, sod, and concrete, which cost $3, $7, $8, $12, and $25 to $30 per square yard, respectively (1993 dollars, Mayo et al., 1993).