8.3 VEGETATED RIPRAP (JOINT PLANTING)

For Example:

8.3.1 Description

Joint planting refers to the insertion of live cuttings (stakes) in the openings or joints between the rock in a riprap revetment, as shown in Figures 8-1 and 8-2. Alternatively, the cuttings can be tamped into the ground at the same time the rock is being placed on the slope face. The latter approach facilitates installation of the cuttings but also complicates rock placement and increases the likelihood of damage to the cuttings if the rock is tailgated or dumped in place.

8.3.2 Objective

Live cuttings placed in this manner should extend into the soil beneath the stone armor, as illustrated in Figure 8-1. The objective is to have these live cuttings root in the soil beneath the riprap, thus reinforcing the bank, anchoring the riprap, and improving drainage by extracting soil moisture.

8.3.3 Effectiveness

A vegetated riprap revetment (joint planting) provides the following advantages:

- It improves the performance of the armor layer by preventing the washout of fines and by reinforcing the underlying native soil.
- It has a more natural appearance and is less visually intrusive than a structural treatment alone.
- It provides some riparian cover and wildlife habitat.
- It helps to slow water velocities near the bank and trap sediment.

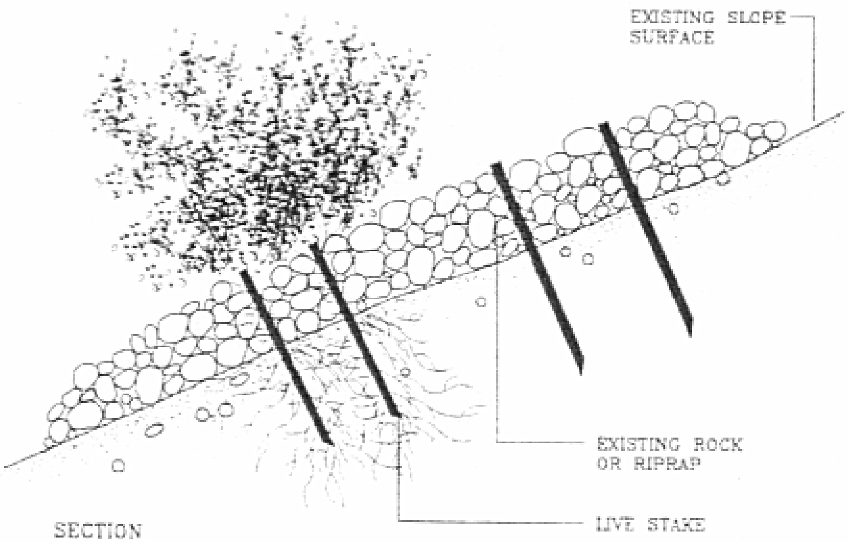


Figure 8-1. Schematic illustration of an established, growing vegetated riprap revetment.

8.3.4 Materials

Live materials consist of cut stakes that are 1 to $1\frac{1}{2}$ inches in diameter and long enough to reach beyond the base of the riprap, as shown in Figure 8-1. Willow cuttings work best for this purpose. The cuttings must be fresh and must be kept moist after they have been prepared into appropriate lengths. They should be installed the same day that they are prepared. The *inert* construction materials consist of rocks, which should be sized to resist dislodgment by waves or currents and a filter course, which should be designed to prevent washout of fines in the native soil beneath the revetment.

8.3.5 Installation

The following general guidelines and procedures can be followed for constructing a vegetated rock revetment on a slope:

- Grade the bank back to a slope no greater than $1\frac{1}{2}:1$ $(H:V)$ and secure the filter fabric on the slope. Place the rock armor layer on top of the filter course, being careful not to damage or puncture the filter layer.
- Tamp the live cuttings into the openings (joints) between the rock. It may be necessary to use an iron bar or rod to create a pilot hole. The latter may also be necessary for penetration through the filter fabric.
- The live stakes should be oriented as perpendicular to the slope as possible with the growing tips protruding slightly above the finished face of the rock, as shown in Figure 8-1. The basal end of the stake must fit snugly in the hole beneath the revetment.
- Tamping the cuttings into the ground is best accomplished with a dead blow hammer (i.e., a hammer with the head filled with lead shot). Avoid stripping the bark during tamping as this will stress and kill the stake.
- Place the stakes in a random configuration in the revetment at a density ranging from two to four cuttings per square yard. The exact placement locations will depend on the positions of openings between the rocks.

For Example:

Vegetated Riprap (Joint Planting)

Joint planting is the insertion of live cuttings into the openings or joints between the riprap stones.

This vegetated riprap plan will use a method of joint planting which calls for placement of fill material and rock overlay on the slope first, then planting of the live cuttings by tamping them through the rock layer and into the soil layer underneath. Live cuttings placed in this manner will have to be long enough to extend through the rock layer and well into the soil below. The objective is to have these live cuttings root in the soil beneath the riprap. This will reinforce the bank, anchor the riprap rock, and improve drainage by extracting soil moisture. This plan intends to leave existing trees growing at the waterline, and will attempt to leave as many existing plants as possible on the slope by pruning them to ground level before placement of the fill and stone layer, and allowing them to resprout through the riprap layer from their roots. Many species will resprout readily.

The vegetated riprap provides the following advantages:

- -It improves the performance of the rock overlay by preventing the washout of fines and by reinforcing the underlying native soil.
- -It has a more natural appearance and is less visually intrusive than the rock layer alone.
- -It provides some riparian cover and wildlife habitat.
- -It helps to slow water velocities near the bank, which helps to trap sediment and build a soil layer.

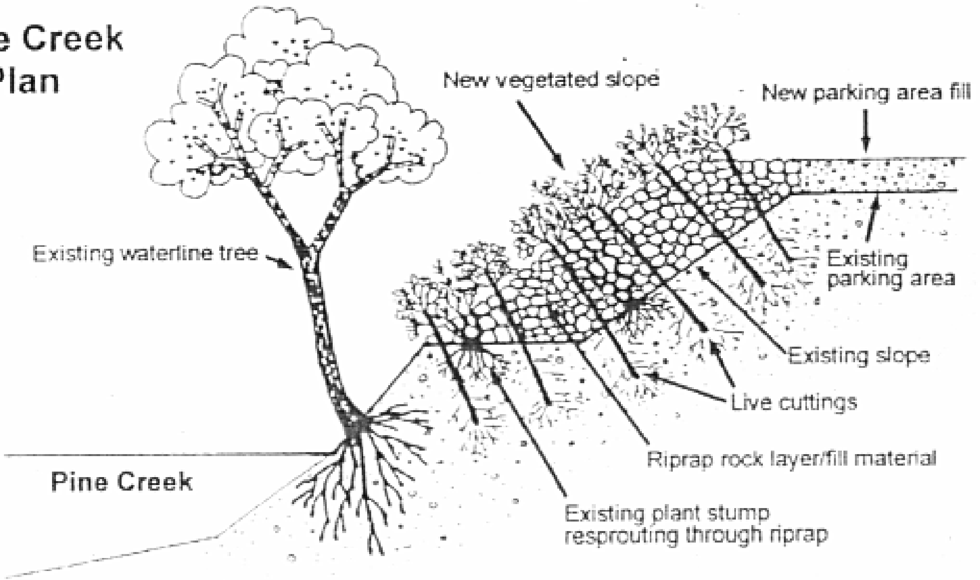
Live Cutting Materials

Live materials consist of cut stakes that are 1 to 1-1/2 inches in diameter. The cuttings must be fresh and must be kept moist after they have been prepared into appropriate length. They should be installed the same day they are cut. Live cuttings will be tamped into the openings between the rock. It may be necessary to use an iron bar to create a pilot hole. The live stakes should be oriented as perpendicular to the slope as possible with the growing tips protruding slightly above the finished face of rock. Tamping the cuttings into the ground is best accomplished with a dead blow hammer. Exact placement of the cuttings will depend on the positions of openings between the rocks.

Slope Protection - Pine Creek Vegetated Riprap Plan

Cross section of Vegetated riprap

Twelve inch riprap stone with indiginous species cuttings placed in joints at six-foot centers. All cuttings shall be taken by a certified nurseryman. All cuttings shall be taken from (at least) five indiginous species. Mature trees growing at waterline to be left intact. Trees in fill area to be pruned to ground level.



Plant Species Available For Cuttings

Trees

Black willow (*Salix gooddingii*)
Sandbar willow (*Salix hindsiana*)
Willow (*Salix lasiàndra*)
Fremont Cottonwood (*Populus fremontii*)
White alder (*Alnus rhombifolia*)
Box elder (*Acer negundo*)
Western sycamore (*Platanus racemosa*)
Blue elderberry (*Sambucus mexicana*)

Understory Shrubs

Coyote bush (*Baccaris pilularis*)
California Wild grape (*Vitis californica*)
Wild rose (*Rosa californica*)
California blackberry (*Rubus vitifolia*)

For Example:

Biotechnical and soil bioengineering stabilization provide attractive, cost-effective, and environmentally compatible ways to protect slopes against surficial erosion and shallow mass movement. This guidebook discusses the general principles and attributes of biotechnical/soil bioengineering stabilization and describes specific soil bioengineering measures that can be employed on slopes, such as live staking, live fascines, brushlayering, branchpacking, live crib walls, and slope gratings. The conjunctive use of plants and earth-retaining structures or revetments is also described. This biotechnical approach includes plantings on slopes above low toe-walls, on benches of tiered retaining walls, and in the frontal interstices, or openings of porous retaining structures, such as crib walls, gabions, and rock breast walls. It also entails the use of vegetation in porous hard armor revetments, such as rock riprap, gabion mattresses, and articulated blocks. The book describes recent developments with biotechnical ground covers or "reinforced grass" systems, which include the use of nets, mats, and other types of structural/mechanical reinforcement to improve the establishment and performance of grass cover on steep slopes or temporary waterways.

Biotechnical and Soil Bioengineering Slope Stabilization distills more than a decade of experience in this subject on the part of both authors into a useful reference handbook. Numerous illustrations from actual field applications and stabilization projects supplement the text. In addition carefully selected and well-documented case studies have been included to show how various soil bioengineering methods have been chosen for particular site conditions. We also include helpful background information on the nature of soil erosion and mass movement, the role and function of slope vegetation in the stability of slopes, and techniques for the selection, establishment, and maintenanceof appropriate vegetation.

Biotechnical and Soil Bioengineering Slope Stabilization is intended primarily as a reference handbook for practicing professionals. Information in the book should prove of value to practitioners in such diverse fields as geotechnical engineering, geology, soil science, forestry, environmental horticulture, and landscape architecture. Although oriented toward professional practice, it is written in such a way that it can be understood by students, laypersons, and other interested parties as well. Analytical or somewhat technical material in some of the chapters can be skimmed over without loss of continuity or utility. Lastly, the book can be used as a reference text in college-level courses, extension courses, and workshops whose course content includes such topics as erosion control, slope stability, watershed rehabilitation, and land restoration.

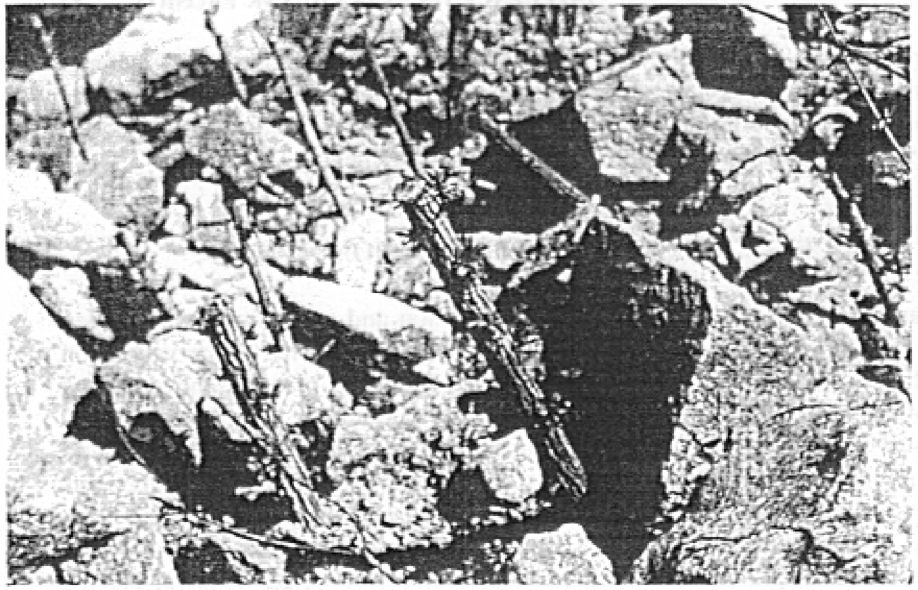


Figure 8-2. Photo of vegetated riprap revetment showing cuttings that have rooted and sprouted between the armor rocks.

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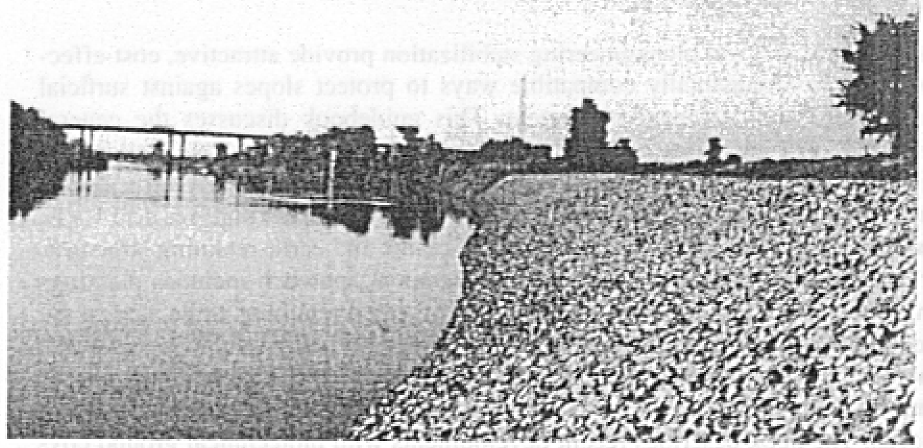
mum seed mix depends on soil, site, and climatic conditions. A horticulturist familiar with local conditions should be consulted for recommendations. Site preparation, mulching, and fertilization may also be required to insure germination and establishment (see Chapter 6 for guidelines).

3.2 INFLUENCE ON STREAMBANK EROSION

Streambanks and levees are subjected to erosion and scour by flowing water. The erosive power of flowing water increases with velocity. Slope vegetation can help to reduce this type of erosion in the following manner: above ground shoots bend over and cover the surface and/or reduce flow velocity adjacent to the soil/water interface, while below ground roots physically restrain or hold soil particles in place. The extent to which vegetation provides these benefits depends upon the surface area of vegetation presented to the flow and the flexibility of the stems. Dense grass swards and low shrubby species that extend numerous nonrigid branches and leaves into the flow (e.g., willows) are the most effective in this regard.

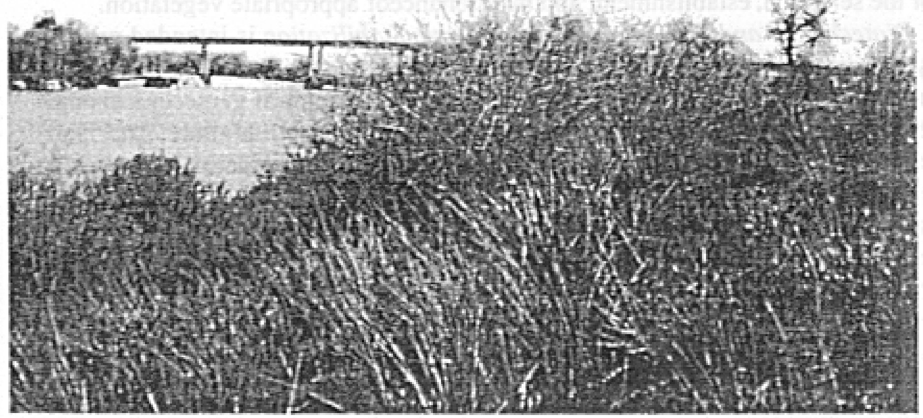
Some controversy exists about the wisdom of allowing woody vegetation to grow on levees, particularly on revetted sections. Objections that have been raised include loss of conveyance from increased roughness, difficulty of inspection, hindrance to flood-fighting operations, and alleged threats to structural integrity as a result of root penetration and subsequent piping. In response to these objections it should be noted that in large rivers, additional channel roughness will have a negligible effect on the stage of the design flood. The effects of vegetation on the structural integrity of sandy levees was investigated by Shields and Gray (1993). They conducted an extensive field study along a 6-mile reach of sandy channel levee adjacent to the Sacramento River near Elkhorn, California. Their study concluded that woody vegetation did not adversely affect the structural integrity of a levee. No open voids or conduits clearly attributable to plant roots were observed in the levee. On the contrary, the presence of plant roots reinforced the soil and increased the shear strength of the surface layers in a measurable manner.

In European practice, vegetation is often promoted as a means of stabilizing both streambanks and levee slopes. In Bavaria, West Germany, a common design practice is to construct widely spaced, vegetated levees. A mixture of plants, including reeds, grasses, and trees, is used with riprap and other standard engineering control measures to retard erosion (Keller and Brookes, 1984). Shields (1991) investigated the influence of woody vegetation growing in a structural, riprap revetment. His investigation showed that the frequency of revetment failure was actually lower in vegetated revetments as opposed to unvegetated sections. Vegetation helps to anchor the armor stones to the bank and increases their lift-off resistance. In addition, vegetated revetments provide riparian benefits and are less visually intrusive, as shown in Figure 3.1.



(*a*)

For Example:



(*b*)

Figure 3-1. Contrasting views of streambank levees. (*a*) Rock riprap alone. (*b*) Vegetated riprap.