G96-1307 Bioengineering for Hillslope, Streambank and Lakeshore Erosion Control

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NebGuide

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Bioengineering for Hillslope, Streambank and Lakeshore Erosion Control

This NebGuide describes bioengineering techniques for hillslope, streambank and lakeshore erosion control. Tips for a successful bioengineering installation and demonstration project are described.

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Soil erosion occurs whenever water meets land with enough force to move soil. Often this occurs along streambanks and lakeshores or where excess water flows over hillslopes. While streambank and hillslope erosion can be dramatic, especially after large rainfalls or floods, normal streamflows, excess runoff from urbanized areas and wave action along lakeshores continually erode soil. Erosion can be severe, as is the case in many man-made lakes, where shorelines are composed of easily erodible soil. Traditional methods of controlling streamflow and wave induced erosion have relied on structural practices like rip rap, retaining walls and sheet piles. In many cases these methods are expensive, ineffective or socially unacceptable. An alternative approach is bioengineering, a method of construction using live plants alone or combined with dead or inorganic materials, to produce living, functioning systems to prevent erosion, control sediment and provide habitat. Bioengineering uses combinations of structural practices and live vegetation to provide erosion protection for hillslopes, streambanks and lakeshores. Bioengineering is a diverse and multi-disciplinary field, requiring the knowledge of engineers, botanists, horticulturalists, hydrologists, soil scientists and construction contractors. It is a rapidly growing field, subject to innovations and changing design specifications. Terms such as biotechnical erosion control, biostabilization or soil-bioengineering are often used synonymously with bioengineering.

History

The use of bioengineering methods dates back to 12th century China, when brush bundles were used to stabilize slopes. In the early 20th century, similar techniques were used in China to control flooding and erosion along the Yellow River. In Europe, especially Germany, bioengineering methods have been used for over 150 years. Documented use of bioengineering in the United States dates to the 1920s and '30s.

Streambank stabilization, timber access road stabilization and slope restoration were common applications. After World War II, with increased access to earth-moving equipment and the development of new structural slope stabilization and erosion control methods, bioengineering practices all but disappeared. In the last 20 years bioengineering has been recognized as a re-emerging technique to provide erosion control, environmentally sound design and aesthetically pleasing structures. Gray and Leiser (1982) published the first U.S. textbook on bioengineering: *Biotechnical Slope Protection and Erosion Control*.

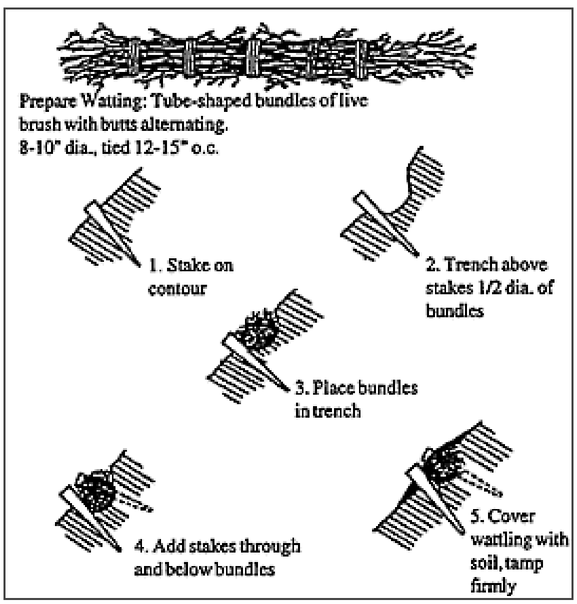
Applications, Advantages and Limitations

Bioengineering solutions can be adopted in many soil stabilization and erosion control situations from streambank and lakeshore protection to upland gully restoration and slope stabilization. Bioengineered restoration of flood or high water damage to streams and lakes provides a more natural-looking solution than traditional rip rap or concrete structures.

Advantages of bioengineering solutions are: 1) low cost and lower long-term maintenance cost than traditional methods; 2) low maintenance of live plants after they are established; 3) environmental benefits of wildlife habitat, water quality improvement and aesthetics; 4) improved strength over time as root systems develop and increase structural stability; and 5) compatibility with environmentally sensitive sites or sites with limited access.

Limitations to bioengineering methods include: 1) the installation season is often limited to plant dormant seasons, when site access may be limited; 2) the availability of locally adapted plants may be limited; 3) labor needs are intensive and skilled, experienced labor may not be available; 4) installers may not be familiar with bioengineering principles and designs so upfront training may be required; and 5) alternative practices are aggressively marketed and often more widely accepted by society and contractors.

Bioengineering Techniques



Homeowners who have streamside or lakeside property, contractors required to work in difficult environmental circumstances or professionals interested in natural restoration of landscapes will find useful bioengineering techniques. New methods of application and materials being developed will result in new and improved bioengineering design.

Contour Wattling

Figure 1. Preparation of wattling and installation procedure. Installation starts at the bottom of the cut or fill and proceeds upslope. Numbered sequence of operations is shown schematically. (From Gray and Leiser, 1982)

This method is used to control surface erosion by breaking long slopes into shorter slopes. Bundles of branches, called wattles or fascines, are placed in shallow trenches along the slope or streambank contour (*Figure 1*). Trenches are excavated by hand to half the diameter of the bundles. Wattles are typically 8 to 10 inches in diameter and branches secured with twine. After the wattle is staked in place, the trench is backfilled until only the top of the bundle is exposed. Wattles can be used for hillslope restoration, road embankments, wide gullies, or slump areas.

Brush Layering

This method is used to restore slopes by constructing a fill-slope consisting of alternating layers of live branches and soil, creating a series of reinforced benches (*Figure 2*). Large quantities of dormant willow branches are often used. While about 75 percent to 80 percent of the branch is buried, the tips are left exposed. The layers of branches help reinforce the fill, which improves as the branches develop roots throughout the fill area. Brush layering can be used to place new fill or repair old fill areas, restore shallow slumps, repair narrow gullies and stabilize loose soil slopes.

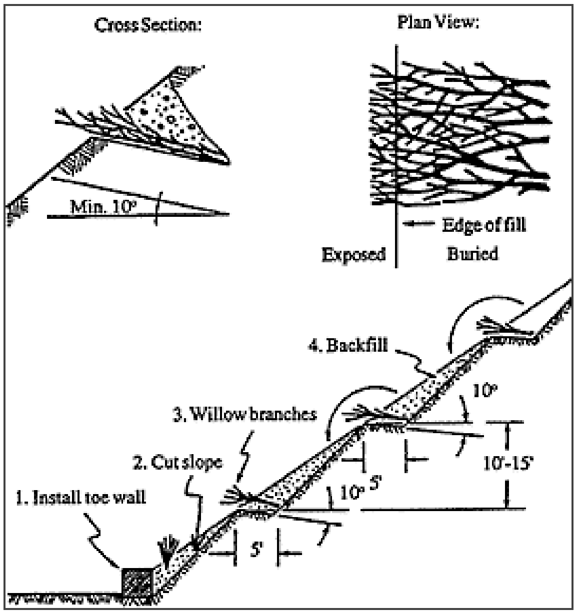


Figure 2. Installation of brush layering. Numbered sequence of operations is shown. Vertical spacing depends on slope angel. (From Gray and Leiser, 1982)

Trench Packing

This method is used to slow or spread water by placing live plants in a trench perpendicular to the flow. To reduce wave impact, live plants are placed in trenches running parallel to the shoreline. Several trenches may be used with different plants in each, depending on the distance to water. Generally, a wide planting area is needed to dissipate wave energy. In upland areas, trench packing serves to slow water and spread it over the soil surface, reducing its erosion potential. Trench packing can also be used to control shallow seeps, protect wetland construction and renovation and protect abandoned roads.

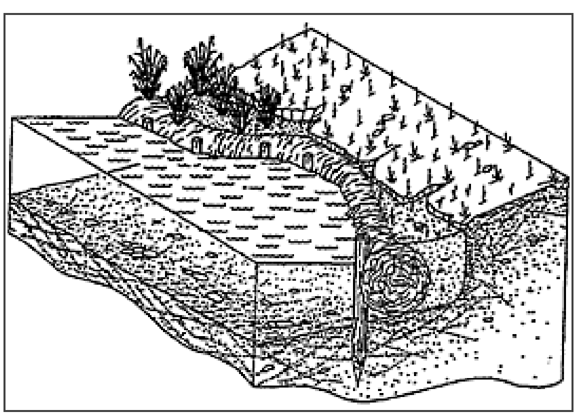
Brush Matting

This method protects streambanks by placing a mattress-like layer of branches over it to protect soil and slow water velocity. The mat is composed of interwoven, usually dead, branches secured to the soil by live stakes, wire, twine or live branches. Live stakes are often cut from dormant willow. Brush matting helps collect sediment and enables establishment of vegetation on banks. Like brush layering, this method requires large quantities of branches.

Live Cuttings

Live cuttings can be used to secure materials in place and to increase plantings on a slope. Live cuttings can be from 18 inches to 4 feet in length. Longer cuttings are used for live staking of wattles, while shorter cuttings are used for plantings.

Coir Fascines



Coir fascines are wattles made from the fibrous outer husk of coconuts. Coir is denser than water so it won't float and is very slow to decay. Coir fascines are a readily available manufactured product and are popular for streambank and wetland restoration where a natural look is desired (*Figure 3*). Coir fascines are placed with their tops at the water surface. Live plants can be placed into coir fascines to create a natural look.

Figure 3. Coir fascines stabilize banks and help establishment of wetland plants. The coconut fiber accumulates sediment and biodegrades as plant roots

develop and become a stabilizing system. (From Bestmann-Green Systems)

Prevegetated Mats

Prevegetated mats are live plants grown on a movable mat of organic material. They come in many sizes and materials and are moved and installed in one piece. They are generally 4 by 8 feet in size for easy handling. Mats are grown in nurseries for up to a year or more to provide a good plant stand. Thin mats can be rolled up and shipped without special packing. Thick mats are handled with heavy equipment because of their weight. Prevegetated mats are made of coir or other slowly degradable material and can use many types of plants. Mats are usually used in wetland or lakeshore environments so wetland plants are the most common. Currently, most prevegetated mats are custom ordered one to two years in advance.

Interplanting Rip Rap

Rip rap is often used to protect streambanks and lakeshores. Rip rap is composed of various size large stones placed on the soil surface where the water contacts the soil. Live cuttings can be interplanted in rip rap to provide additional slope stability. Root growth below the rip rap will improve soil strength and live vegetation will hide the rocks, presenting a more natural look.

Staking

Staking is used extensively in bioengineering practice. Stakes can be live or dead. Live staking is often done with willows to stabilize soil or to stake other materials in place. Manufactured timber stakes, 2 to 3 feet long, are used to secure wattles and coir fascines. Timber stakes for upland application need to have a bias, or angle, cut making them easier to install. For wetland or streamside applications, stakes need straight parallel sides to prevent heaving from water pressure.

Combinations

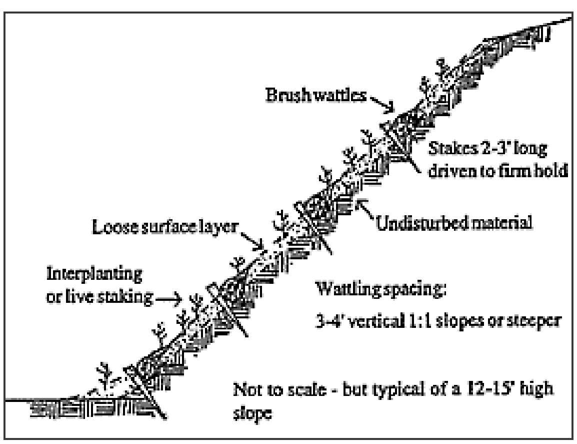


Figure 4. Slope treatment using wattles and live plants or stakes. Use for loose surface soils with sheet, rill or small gully erosion. (From A.T. Leiser)

Combinations of the above practices are usually used for most bioengineering designs. For example, brush wattles and live staking is a common combination used to stabilize slopes (*Figure 4*). A coir fascine can be used with live plantings, brush matting and trench packing to restore wetlands or stream channels (*Figure 5*). New combinations of existing methods, and the use of new materials, will provide creative applications of bioengineering techniques.

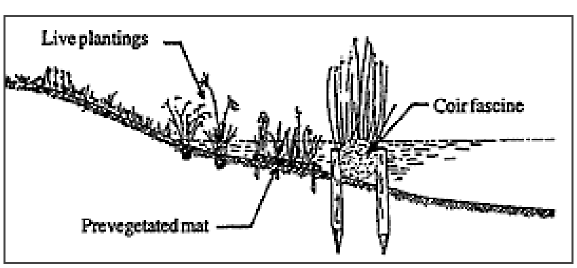


Figure 5. Lakeshore erosion control using a combination design of coir fascine and wetland plantings, prevegetated mat and live plantings. (From A.T. Leiser)

Plantings

Bioengineering involves the use of live plants to add structural strength to soil. Many different plant materials are used. Live cuttings should be soaked in cold water for at least 24 hours before they are used. This not only provides the cuttings with needed moisture but also improves rooting. Live potted plants are often used. Care of live plants before and during planting is critical for success. Live plants raised indoors need to be acclimatized to the outdoor environment before planting.

Plants can be planted directly into coir fascines, coir pots or mats. Prevegetated mats, as described earlier, are another method used to transplant live plants. A plant roll can be developed by wrapping several live plants in a roll of degradable material and placing the roll in the ground like a wattle. This method also can be used for trench packing.

Seeding can be used where appropriate. Seeding and mulching are not appropriate in areas of flooding, high water flow or rapid changes in water depth, as the mulch and seed will be washed away. Proper seedbed preparation, fertilization and irrigation may be needed to assure seedling survival.

Expect some failure of plantings in all bioengineering application. A 75 percent to 80 percent survival rate is considered very good. Replanting is generally inexpensive and often the plants will reestablish themselves in time. Some loss of vegetation does not seriously impact a project as long as most of the soil stays in place and the structural features of the design are sound.

Protect Plantings

Protect live plantings from animals, especially ducks and geese along lakeshores and streamsides. Deer, muskrats, beaver, dogs and humans can also pose a threat. Signs may keep people away, but fencing may be needed if animals are a problem. For lakeshore or streamsides, an enclosed fencing layout is best to keep waterfowl away. One fence should be placed 1 to 2 feet into the water away from the shoreline plantings with a parallel fence 2 to 3 feet upslope from the plantings. Also, protection from flooding or excess water flowing across the planting is important to establish all bioengineering plantings. Be sure surface drainage and water flow is directed away from the new plantings or protected slope.

Vegetation Type

Selection, procurement and installation of the proper plant material is essential for a successful design. In the case of lakeshore and streambank protection, both herbaceous and woody plants are needed. Herbaceous plants, or wetland plants, will be needed at and near the water's edge. These plants can grow with their roots underwater. This root growth adds considerable strength to the soil. Generally, using several different wetland plant species increases the chance of a successful planting. However, woody plants placed too near the water or water table will not provide good structural strength and may not survive. Woody plants should be used on the upper slope and upland areas where their roots can grow in soil above the water table.

Native vegetation existing at or near the site will give good guidance concerning plant selection. As mentioned, willow cuttings are often used for wattles and live cuttings. Proper species selection is important. Willows need not be native, but should be well adapted to the region. The use of introduced species allows the potential for increasing the number of different species available.

The availability of plant species, in the appropriate size and quantity, is often a limiting factor in the final selection process. Local nurseries may not carry the types of wetland plants needed. They may be able to propagate the species needed, but this will take 12 to 18 months. A compromise between use of native species and what may be locally or regionally available will be needed to develop a successful design. Consult horticulturalists and botanists for plant selection assistance. The International Erosion Control Association (IECA) publishes a products and services directory listing sources of plant material and professional assistance (see references for address).

Improving Success With Bioengineering

Bioengineering can be effective in many streambank, lakeshore and hillslope erosion situations, but it will not solve all soil erosion or slope failure problems. The success of a project hinges on many factors including proper design, plant selection, proper installation, weather conditions and outside factors like animal damage. Site evaluation is important to determine whether there is adequate sunlight, soil type and water quality to support vigorous plant growth. Do not expect bioengineering solutions to stop slope failure caused by high water tables or landslides. Nor are they ideal for high stress areas with severe wave action, rapid or long-term water level fluctuations or fast water flows. The following list includes tips that may help ensure a successful bioengineering project.

1. Do not attempt bioengineering solutions in situations where: 1) there is severe soil or water contamination; 2) the stream bottom is degrading; 3) you can not control human or animal traffic at the site; or 4) there is too much shade for selected plant species to thrive.
2. Check with local, state and federal regulatory agencies before beginning the project. Do not alter a wetland area without proper permits. In Nebraska, check with the local Natural Resources District or the Natural Resources Conservation Service to inquire about permits.
3. Water elevation is the most critical element in a successful installation. Be sure you know the normal, high and low water elevations for the site. Know the seasonal changes in water elevation and how rapidly these changes occur.
4. Be sure to fence out animals and people, if needed. If damage occurs, supplemental planting may be necessary.
5. Be aware of flood or drought conditions that could impact your installation. Severe weather will reduce seedling survival. Supplemental planting may be needed.
6. Provide regular monitoring and maintenance, especially in the first year, to assure adequate plant survival.
7. Plan ahead. Involve the proper design professionals and experts to provide information on hydrology, plantings and structural design. A multi-disciplinary approach will assure success.

When To Seek Expert Help

There are bioengineering consultants available to help with all aspects of site assessment, design and installation. Their input could make the difference between success or failure. Use the IECA Products & Services Directory to seek out professional assistance (see references for address). Many bioengineering techniques can be used successfully without input from consultants, however it is best to consider expert help if characteristics of your site are such that: 1) stream velocities are greater than 3 to 5 feet per second; 2) streambank heights are greater than 3 feet; or 3) wave impacts are from waves greater than 1 foot high.

Tips For A Successful Demonstration

Demonstration projects can help show the advantages and benefits of bioengineering solutions. Keep demonstration projects small, from 100 to 500 feet in length for most situations. A smaller project puts less property and dollars at risk. A demonstration lets you evaluate what methods or plant species perform best under similar conditions. Incorporate some variety into the project so you can compare differences. To start, choose a simple project, in a low impact area, with a low profile or incorporate some bioengineering methods into larger projects and collect data to evaluate their success. Provide adequate maintenance and keep good monitoring records. Schedule agency personnel and public visits to the site to maximize public relations. Plan to hold these visits during installation and again after one growing season.

References

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