Bioengineering for Brahmaputra

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Potential bioengineering techniques for erosion control in Brahmaputra river

Soil bioengineering is the use of plant material, living or dead, to alleviate environmental problems such as shallow, rapid landslides and eroding slopes and stream banks. In bioengineering systems, plants are an important structural component. This approach to slope stabilization requires a true partnership among many disciplines, including soil scientists, hydrologists, botanists, engineering geologists, maintenance personnel, civil engineers, and landscape architects

Cont..

Soil bioengineering most often mimics nature by using locally available materials and a minimum of heavy equipment, and it can offer an inexpensive way to resolve local environmental problems. These techniques can also be used in combination with traditional engineering techniques such as rock or concrete structures.

Bioengineering Techniques

Integrated techniques using in conjugate with ecological principles to construct vegetative living system to prevent erosion.

Combines principles of ecology ,hydrology and physics.

Involves using living plant materials to built structures (living fence) that reduce erosion.

More effective over conventional structures.

Are aesthetically pleasing self maintaining, less expensive and streamside habitat for wild life and fish.

Restore overall condition of stream.

Bioengineering Applications

- Steep slopes
- Cut and fill slopes
- Landfill covers
- Spoil banks

Plants used for bioengineering

- Vetiver,
- Bamboo,
- Utis,
- Katus,
- Eucalyptus,
- Chilaune,
- Kutmiro,
- Kafal tree,
- Amriso,
- Napier,
- Stylo,
- Molasses,
- Babiyo,
- Kans

Image Source:http://www.bamboogarden.com/care.htm

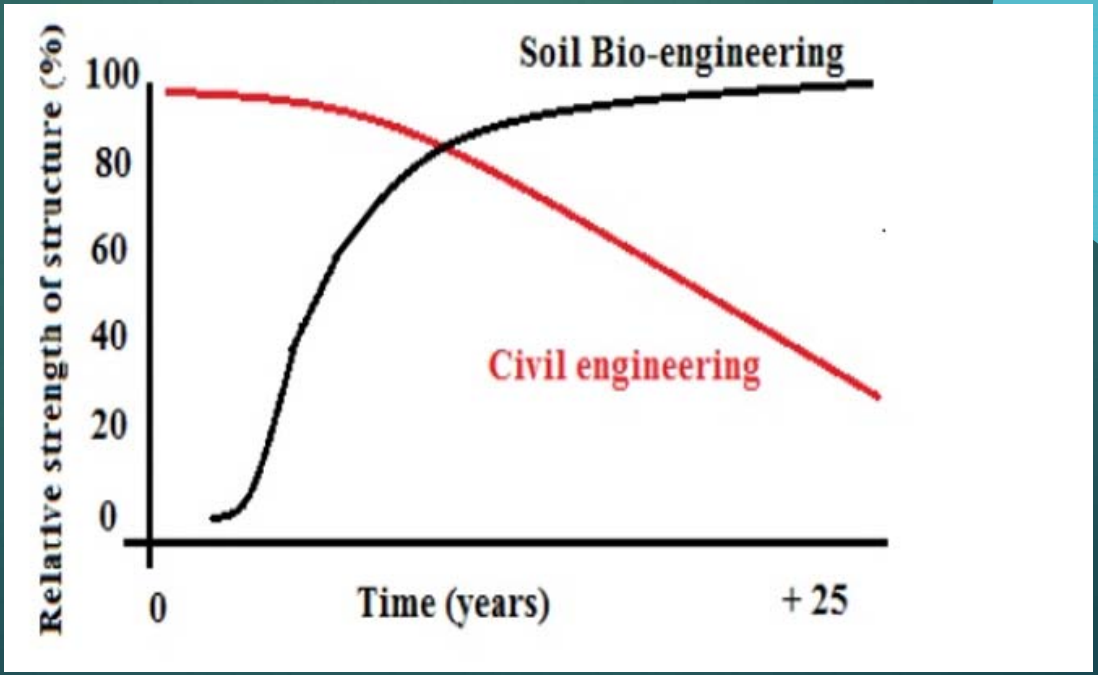
Criteria for the selection of plants

The choice of plants for biotechnical structures does not only depend on root strength characteristics but on factors such as;

- Ecological amplitude (aspects of plant-sociology and plant geography
- Succession
- Propagation
- Growth qualities (speed and patterns of growth, juvenile growth behaviour),
- Soil stabilization and anchoring qualities of the root system
- Physical and chemical soil characteristics
- Climatic aspects

Comparison between hard engineering & soil bioengineering

- One of the important benefit of bioengineering compared to “hard” engineering is its capacity to increase its resistance over time.



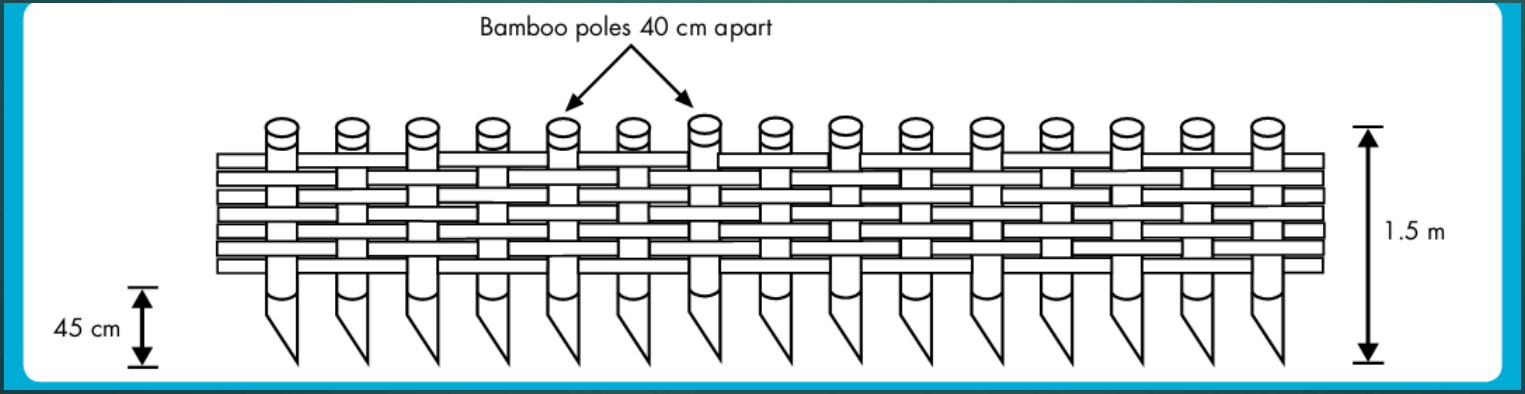
Merits and Demerits of SBE/SBP

Advantages	Limitations
▪ Economy	▪ Installation season
▪ Environmental compatibility	▪ Availability of plant material
▪ Maintenance	▪ Labour considerations
▪ Improved strength over time	▪ Time for installation
▪ Access	▪ Installation procedures

Common Bioengineering Techniques

Bamboo fencing

- Bamboo fencing can be used to prevent soil creep or surface erosion on a slope to hinder gully extension, particularly in seasonal water channels, and to control flood waves along a river bank.
- Live bamboo pegs can be used for the main posts so that the whole structure becomes rooted. The growing bamboo can be further interleaved between the posts (as in a wattle fence) to increase the strength of the fence. Shrubs and grasses are planted on the upper side of the fence to hold small soil particles.
- The main purpose is to trap loose sediments on the slope, to improve the conditions for growing vegetation, and to reduce the surface runoff rate.



Materials

1. Live bamboo pegs or strong bamboo poles about 1.5 m long and 10–15 cm in diameter.
2. Digging tools.
3. Seeds or plants of grasses or shrubs.

Installation

1. Starting from the base of the slope, mark the line for the fence with string.
2. Dig a long pit about 45–50 cm deep along the contour of the slope for each line of fencing.
3. Insert a row of bamboo poles or pegs 40 cm apart into the pit and back fill the pit to stabilize the poles.
4. Weave split bamboo or branches in and out between the poles to form a semi-solid face.
5. Plant small grasses and/or shrubs along the upper side of the fence.
6. Regular maintenance is important to ensure longevity of the fence. Any broken sections should be replaced immediately.

• Vetiver

- Vetiver is a perennial grass belonging to the family Poaceae.
- In the World topics, about 11 species are available,
- two species are found in India.
- (*Vetiveria lawsonii &Vetiveria zizanioides)*
- More than 100 countries like China,
- Australia, Vietnam, Thailand, Philippine, etc.
- are using vetiver grass for river bank & Dyke.
- According to Islam & Arifuzzaman (2010), from in situ test the shear strength of vetiver rooted soil is 78% higher than that of bared soil and failure stain is about 515% higher
- For a particular soil, the factor of safety of vetivered embankment is 1.8 to 2.1 times than the normal one without vetiver.

Why vetiver is chosen ?

1) Tolerance to extreme climatic variation.

2) Ability to re-grow very quickly after being affected by drought, frosts, salinity

3) Tolerance to wide range of soil pH from 3.3 to 12.5 without soil amendment.

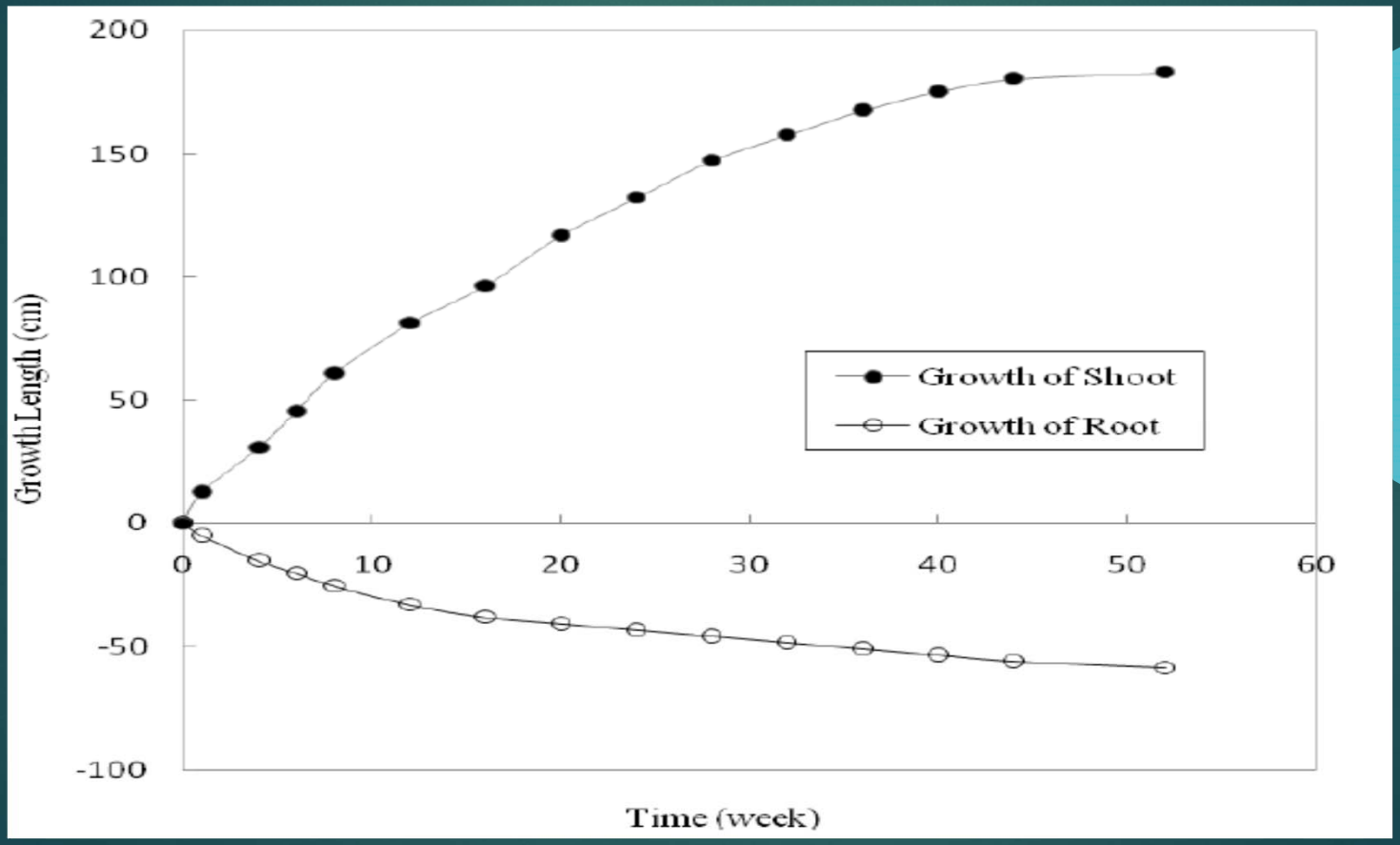
4) High level of tolerance to herbicides and pesticides.

5) Highly efficient in absorbing dissolved nutrients such as N and P and heavy metals in polluted water.

6) Highly tolerant to growing medium high in acidity, alkalinity, salinity, sodicity and magnesium.

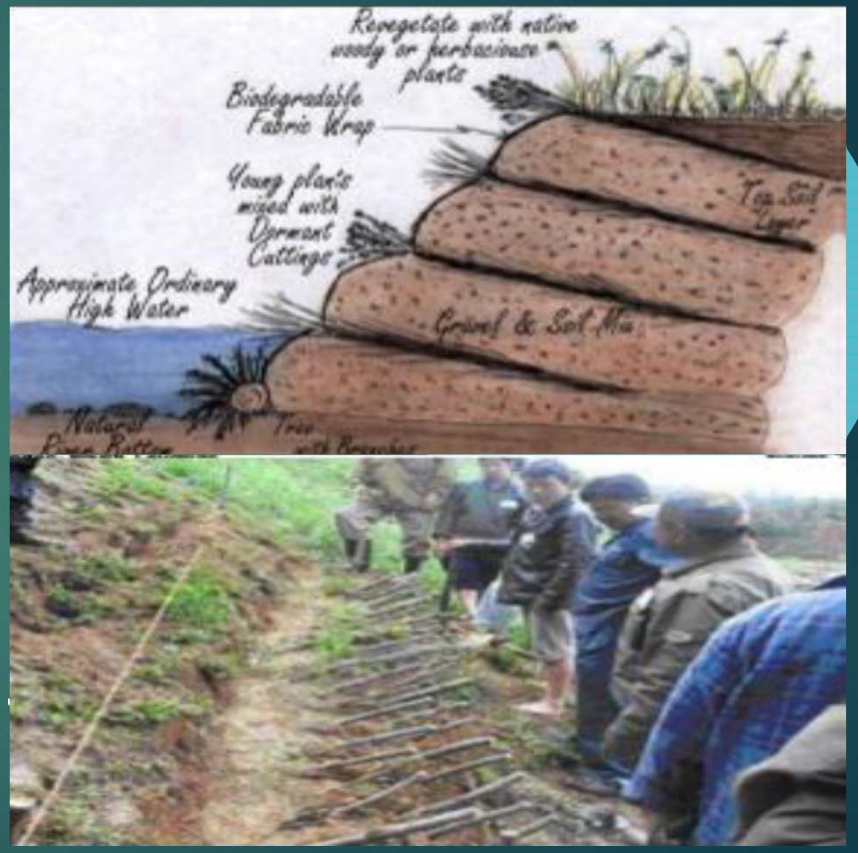
7) Highly tolerant to Al, Mn and heavy metals such as As, Cd, Cr, Ni, Pb, Hg, Se and Zn in the soils.

Time versus growth of shoot and root of vetiver



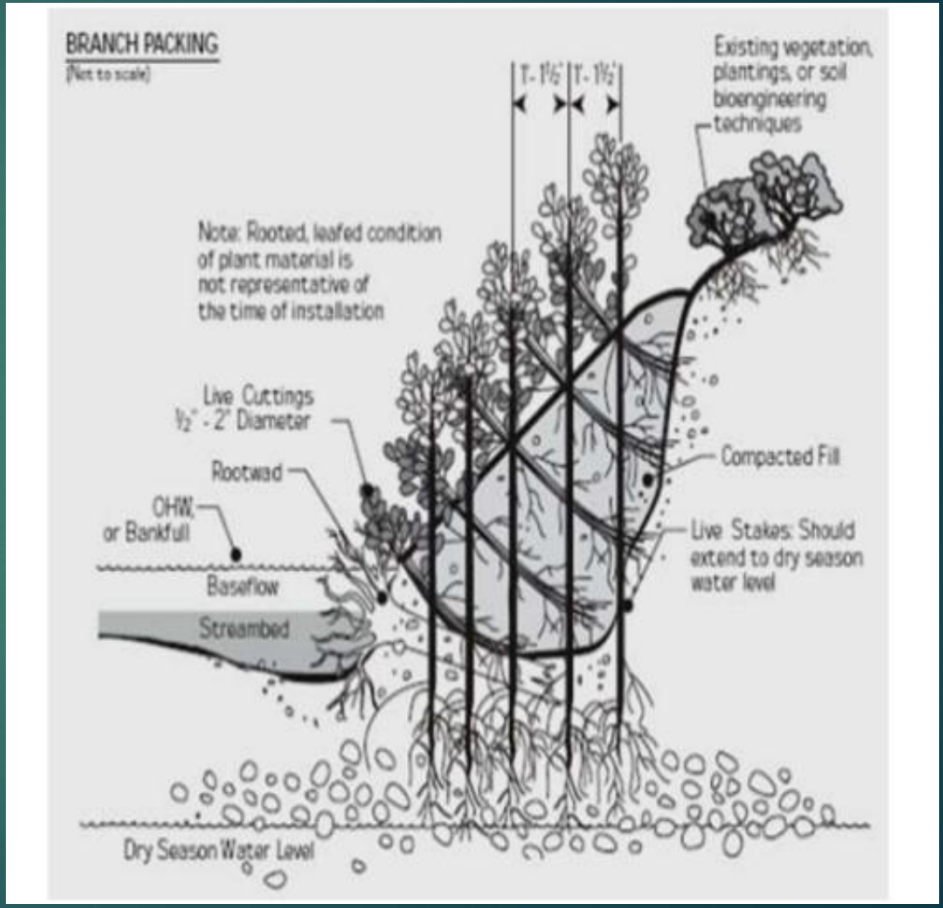
Brush Layering

- Brush layer is a layer of plant material intercepted between layer of soil on cut slopes or fill slopes.
- Made of live cutting planted in lined, on terraces across the slope, covered with soil.
- Re-vegetation technique, combines layer of dormant or rooted cutting with soil.
- Brush layers act as live fences to capture debris moving down the slope.



Brush layering cont..

- Primary use to minimize bank erosion & additional use enhances aesthetics
- Works better on fill than cut slopes because of use of longer stems in fill.
- Used to stabilize a slope against mass wasting & erosion protection.



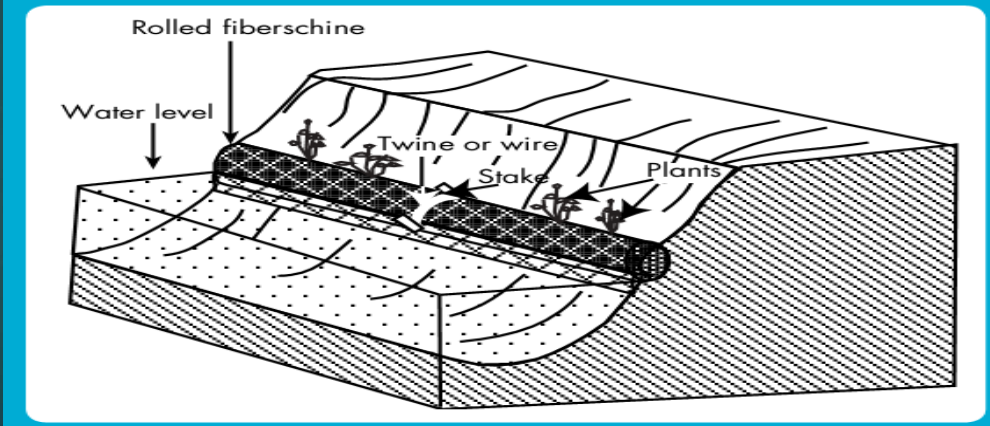
Brush layering

Row of brush layer being planted

Brush layer established after 2 years of planting

Fiberschine (adapted from Bentrup and Hoag 1998)

- Fiberschine is a roll of material made from coconut fibre used to form a toe protection structure on a slope and to trap any sediment derived from erosion.
- The most common use is to stabilize the base of a stream bank or shoreline, but it can also be used in slope stabilization to support other measures such as brush layering. Live cuttings from herbaceous plants are planted together with the fiberschine; by the time the fiberschine decomposes, the vegetation will have stabilized the stream bank or slope.
- Fiberschine can usually be installed throughout the year, but the high water season should be avoided along streams.



Source: Modified from Bentrup and Hoag et al. 1998

Materials

1. Sharpened stakes from plants 1 m long and 4–6 cm in diameter
2. Shorter stakes 0.5 m long and 3–4 cm in diameter
3. Long and flexible woody cuttings from plants which can root easily
4. Jute or coir string or wire to bind
5. Digging tools

Installation

1. Prepare the site by clearing all loose material and protrusions.

2. Mark lines along contours on the slope where the fences are to be installed. Fences should be spaced at intervals of about 4–5 m down the slope, depending on the site and slope angle.

3. Dig holes at 1 m intervals along the lines for the stakes.

4. Insert 1 m long stakes in the holes and place two 0.5 m long stakes at equal distances between the long stakes. Both long and short stakes should protrude about

   20–30 cm.

5. Dig out a trench at least 15 cm deep along the contour between the stakes.

6. Place the cuttings with their lower ends in the trench, and bend them down along the line of the fence. Firm the soil back into the trench. Weave the cuttings in and out between the stakes one above another to fill in the fence area.

7. If desired, add soil above the wattle fence for planting tree and grass seedlings and cuttings.

8. Regular supervision and maintenance is necessary, including weaving the branches in and out as they grow

Contributions of plants to bank (slope) stability

Hydrological Function:

Plants play a significant role in the hydrological cycle. Particularly riparian vegetation influences hydrological processes through effects on runoff; control of uptake, storage, and return of water to the atmosphere; and water quality (Tabacchi et al. 2000).

Interception:

Restraint: The dense network of coarse and fine roots physically binds and restrains soil particles in the ground, while the above ground portions filter sediment out of runoff.

A**bsorption:** Roots absorb surface water and underground water thus reducing the saturation level of soil and the concomitant risk of slope failure.

I**nfiltration:**.

E**vapotranspiration:** Vegetation transpires water absorbed through the roots and allows it to evaporate into the air at the plant surface.

S**urface runoff reduction**: Stems and roots can reduce the velocity of surface runoff by increasing surface roughness.

S**tem flow:** A portion of rainwater is intercepted by trees and bushes and flows along the branches and stems to the ground at low velocity. Some rainwater is stored in the canopy and stems.

Other criteria for the selection of plants

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