VEGETATED RETAINING WALLS – A SUSTAINABLE BIO-ENGINEERING METHOD TO STABILISE SLOPES

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Stabilization of natural and man-made slopes across different regions in Sri Lanka is a major engineering problem. The conventional approach of constructing retaining structures like masonry, concrete, or gabion walls has traditionally been adopted for enhancing slope stability. However, the cost of building and sustaining these traditional systems keeps rising with each passing year. Therefore, soil bioengineering has been demonstrated to be a cost-effective and sustainable option where vegetation is supplemented with structural elements to enhance slope stability. One such bioengineering application is the vegetated crib wall, a gravity retaining structure with a special form of structural support with live vegetation. A crib wall is typically composed of a framework of various materials filled with in-place soil or other fill material. In the current study, bamboo was used as the primary structural material due to its renewable nature, strength, cost-effectiveness, and ecological sustainability. The walls of the bamboo cribs were incorporated with live plant cuttings or vegetation roots, constituting a living system that not only provides immediate structural strength but also assists in long-term slope strengthening through root growth.

In this research, numerical modelling is employed in PLAXIS 2D software to determine the stability of bamboo crib walls. For two most vital stages: (1) instant stage following the construction when there is limited vegetation contribution and (2) after that bamboo-growing stage, the root system strengthens slope stability through natural processes, two approaches of assessment are based on factor of safety (FOS), serving as a chief measure of stability of slope.

Comparative analysis between concrete crib and bamboo walls indicated that while bamboo walls offer slightly lower FOS initially, they enhance long-term slope stability considerably because of vegetation growth. Further studies were carried out to investigate the effect of important design parameters on FOS, including wall width, embedment length, water table level, and the type of fill material used. Observations indicate that wall width, embedment depth, and elevation of the water table are good indicators of the overall stability of bamboo crib walls. Vegetation, including bamboo, was found to extend functional life of the structure and long-term slope stability. The study analyzed how water table levels influence the factor of safety (FOS) using wall widths of 1.5 m, 2.0 m, and 2.2 m. Two water table shapes; horizontal and inclined were examined. Bamboo was considered non-porous, while both existing and fill soils were treated as drained materials

Also, design parameters such as base slope, the angle of the crib wall was found to be crucial parameters that needed more analysis. Incorporating drainage in the crib wall was also suggested to enhance overall performance. Finally, a detailed cross-sectional design of the bamboo crib wall with structural and vegetative components is illustrated based on the findings of this research.

Keywords: Bamboo, Crib wall, Root reinforcement, Slope stability, Soil bioengineering

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VEGETATED RETAINING WALL

A sustainable Bio-Engineering Method to stabilize slopes

Problem

Land Slide
and Slope Failure

Traditional Concrete / Gabion wall

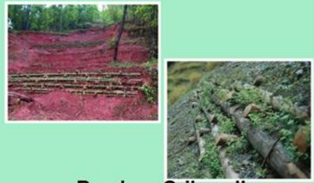
Gabion wall

Environmental Impact
Long term stability
Cost

30.5 m long 15 m high walls in Nepal rupees

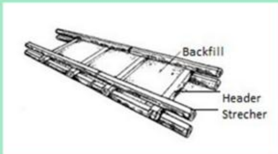
- *Bamboo Crib wall 1708*
- *Stone Masonry 9500*
- *Gabion wall 8250*

Vegetated cribwall

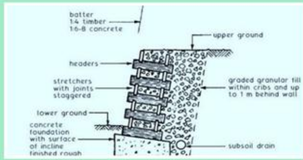


Bamboo Crib wall

Extensine Literature Review of Vegetated Crib Wall



Typical crib construction.



Crib Retaining wall

Choose a vegetation Material for crib wall, and Identify Material Properts of vegetation Crib wall

Materials	Young's Modulus (N/mm^2)	Compressive Strength (N/mm^2)	Tensile Strength (N/mm^2)	Bending Strength (N/mm^2)	Shear Strength (N/mm^2)
Bamboo (*Bambus*)	20000	62-93	148- 384	76-276	19.8
Birch (*Betula*)	16500	43	137	125	12.0
Common hornbeam (*Carpinus*)	16200	66	135	13	8.5
Larch (*Larix*)	13800	47	107	99	9.0
Common Ash (*Fraxinus*)	13400	44	165	12	12.8
Oak (*Quercus*)	13000	65	90	100	11.0
Teak (*Tectona*)	13000	68	119	105	9.0
Common Alder (*Alnus*)	11700	55	94	85	4.5
Spruce (*Picea abies*)	11000	50	90	78	6.7
Poplar (*Populus*)	8800	35	77	65	6.5
Steel St 37, DIN 18800	210000	218	218	218	126

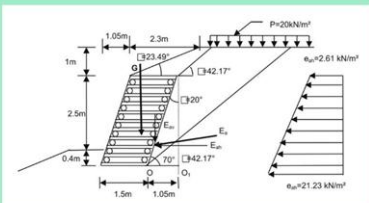
A Strength comparison of bamboo

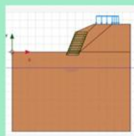
Bambusa vulgaris

- Sri Lankan Climate Conditions
- High vegetative propagation ability
- High Flexibility
- High Tensile Strength

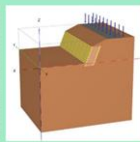
Develop Numerical Model To check stabiliby

Design Example for the Validation



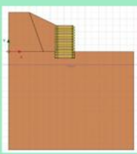


2D Model

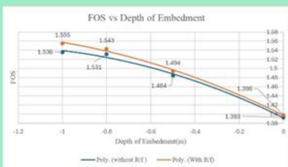


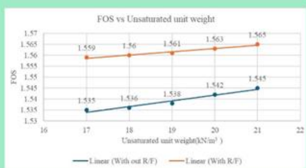
3D Model

Analyse the results



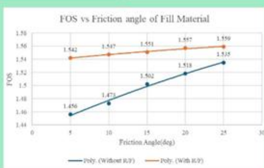
Analysis Model





Evaluated two stages

- *Soon after construction*
- *Bamboo grows (natural stabilized slopes with root growth)*



Conclusion

Vegetation growth improves Fos; wall width, embedment depth, and watertable depth are critical influences on slope stability.
Bamboo crib walls offer the best bioengineering solution for slope stabilization.

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