

Keynote Presentation

Vetiver System for Erosion and Sediment Control, and Stabilisation of Steep Slopes (With special references to the Ho Chi Minh Highway, Vietnam)

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EXTENDED ABSTRACT

Slope Stability

The stability of natural slope, cut slope, road batter etc is a function of: rock/soil type and its strength, slope geometry (height, angle), climate, vegetation and time. Each of these factors may play a significant role in controlling driving or resisting forces.

- **Driving forces.** Although gravity is the main driving force, it cannot act alone. Slope gradient, angle of repose of specific soil, climate, slope material, and especially water, contribute to its effect.

- **Resisting forces.** The main resisting force is the material's shear strength, a function of cohesion (the ability of particles to attract and hold each other together) and internal friction (friction between grains within a material) that opposes driving forces.

Vegetative Slope Stabilisation

Vegetation has been used as a natural bioengineering tool to control erosion and stabilize slopes for centuries, and its popularity has increased markedly in the last decades due partly to more information about vegetation is now available to engineers, and also partly due to the cost-effectiveness and environment-friendliness of this “soft” engineering approach.

A slope will become unstable due to:

- **Surface erosion** or ‘sheet erosion’ if not controlled often leads to rill and gully erosion that, over time, will destabilize the slope. The vegetative cover provided by grass seeding, hydro-seeding or hydro-mulching normally is quite effective against sheet erosion and small rill erosion

- **Internal structural weaknesses** will ultimately cause mass movement or landslide. Deep-rooted plants such as trees and shrubs can provide some structural reinforcement for the ground.

Characteristics of Vetiver Suitable for Slope Stabilisation

Although botanically a grass, Vetiver plants used in land stabilisation applications behave more like fast-growing trees or shrubs.

- ***Deep and massive finely structured root system*** can extend down to two to three meters (six to nine feet) in the first year, which binds the soil making it very difficult to dislodge, and extremely tolerant to drought.
- ***As strong as or stronger*** than those of many hardwood species, Vetiver roots have very high tensile strength that has been proven positive for root reinforcement in steep slopes.
- ***High design tensile strength*** of about 75 Mega Pascal (MPa), which is equivalent to 1/6 of mild steel reinforcement and a shear strength increment of 39% at a depth of 0.5m (1.5 feet).
- ***Form dense hedges*** when planted closely together, which reduce flow velocity, spread and divert runoff water, and create a very effective barriers that control erosion and trap sediment.
- ***High tolerance to extreme climatic*** and environmental variations, including prolonged drought, flooding and submergence, and temperature extremes ranging from -14°C to 55°C (7° F to 131°F)
- ***High tolerance*** to soil acidity, salinity, sodicity and acid sulphate

Appropriate Designs and Techniques

As a soil conservation technique and, more recently, a bioengineering tool, the effective application of VS requires an understanding of biology, soil science, hydraulics, hydrology, and geotechnical principles. Therefore, for medium- to large-scale projects that involve significant engineering design and construction, VS is best implemented by experienced specialists rather than by local people themselves. Failures of VS can, in most cases, be attributed to bad applications rather than the grass itself or the recommended technology.

Experience in Vietnam shows that Vetiver has been very successful employed when it is applied correctly. To ensure success, it must be stressed that the most important keys are good quality planting material, proper design, correct planting techniques and initial maintenance plan.

Advantages of the Vetiver System

- ***Low cost and longevity.*** The savings are in the order of 85-90% in China and 64% to 72% in Australia. VS is particularly well suited to country with low-cost labour force.
- ***A natural, soft bioengineering technique,*** an eco-friendly alternative to rigid or hard structures, particularly on poor and highly erodible and dispersible soils
- ***Low maintenance*** in the first two years; however, once established, it is virtually maintenance-free. Therefore particularly suited to remote areas where maintenance is difficult.

Disadvantages of the Vetiver System

- ***Fully effective only when the plants are well established*** and form closed hedgerows.
- ***Difficult to plant*** and water on very high or steep slopes.
- ***Protection from livestock*** during its establishment phase.

Applications of VS in Natural Disaster Mitigation and Infrastructure Protection in Vietnam

VS was first introduced to Vietnam in January 1999, for soil and water conservation in farm lands and environmental protection purposes. Eight years later in 2007, VS has been used

extensively for road, beach dunes and riverbank stabilizations, flood protection and sea dikes, fresh and marine aquaculture ponds, and in cassava, coffee and cocoa plantations throughout the country.

Erosion and Sediment Control on the Ho Chi Minh Highway

The most visible and perhaps most successful application is the use of VS to protect the newly built **Ho Chi Minh Highway** against tropical storms and cyclones. Most of this highway follows the old Ho Chi Minh trail, built during the war, through very rugged mountainous tropical rainforest. It stretches over 3 000km from the cold and frosty mountains on the Chinese border in the north to the swampy acid sulfate soil in the gulf of Thailand in the south.

Due to its very inhospitable climate and poor soils, most of the conventional hard structures built to protect its batters failed, both structurally and economically. VS was tried as a last resort and has proved to be “spectacularly” effective and successful. Most of its northern and central sections of this highway so far have been effectively protected by VS, the southern section is being constructed. Wherever suitable, most of the batters are planted by just vetiver on rolling steep hills up to 100m high, but also in many places it is incorporated neatly with rocks and concrete structures. On a recent survey, over a stretch of 500km in the northern section, where VS was applied correctly only one serious failure was noted, due to underground seepage on a recent planting. This very impressive result has been achieved through lesson learnt from earlier failures due to inappropriate design and implementation techniques such as lack of benches on very high and steep slopes.

Keywords: slope stabilisation, erosion sediment control, land slide,

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Links to well-illustrated websites:

<http://picasaweb.google.com/VetiverClients/VetiverSystemAndRuralRoads>

<http://picasaweb.google.com/VetiverClients/VetiverSystemsForHighwayStabilization>

<http://picasaweb.google.com/VetiverClients/VetiverSystemAndRairoadProtectionAndStabilization>

http://www.Vetiver.org/ICV3-Proceedings/IND_vetoil.pdf

A Brief Introduction to the Speaker

Dr. Paul Truong, a Board Director and Asia and Oceania Representative of The Vetiver Network International, and recently Principal Consultant of Veticon Consulting. In the last 20 years he has conducted extensive R&D and Application of the Vetiver System in erosion and sediment control, land rehabilitation and environmental protection in tropical and subtropical Australia, Asia and Africa.

His pioneering research on vetiver grass tolerance to adverse conditions, heavy metal tolerance and pollution control has established the benchmark for VS applications in wastewater treatment, toxic wastes and mine rehabilitation which he has won several World Bank and the King of Thailand Awards.