Global Review on the Application of Vetiver System for Infrastructure Protection

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Common Types of Slope Instability

1. Surficial erosion
2. Shallow mass movement
3. Slides, slips, deep-seated mass movement, failure
Options for slope protection:

1. Hard structure
2. Combination of hard and soft structure
3. Bioengineering alone
Some Special Characteristics of Vetiver Grass Suitable for Bio-Engineering.

1. Extremely deep and massive finely structured root system, with high tensile and shear strength
   • Potential pore pressure reduction, and extremely tolerant to drought.
   • Increase soil structural strength

2. Dense hedges when planted close together
   • Spreading runoff water, reducing flow velocity,
   • Forming a very effective filter to trap sediment

3. Tolerance to extreme climatic variation
   • Prolonged drought, flood, submergence
   • Extreme temperature from -14°C to 55°C.
Deep, penetrating and high shear strength root system

3m deep on a fill batter in Malaysia

Landslip

Broken concrete

Penetrating roots through compacted earth

Roots
Application of VS in combination with other materials

To enhance the establishment of vetiver grass under adverse conditions, other materials such as:

- Jute mat
- Geotextiles
- Eco-mortar
- Sand bags

A mixture of cement, sand and cellulose.
A combination of concrete drains and vetiver are used to stabilise this very steep and highly erodible batter in Thailand.
Very high and steep slope in Vietnam

Before

After Vetiver planting
Without Vetiver reinforcement, concrete blocks by themselves could not protect slope in long term.
Vetiver used in combination with concrete block

Without Vetiver reinforcement, concrete blocks by themselves could not protect slope in long term
CASES STUDY OF GLOBAL APPLICATIONS OF VS FOR INFRASTRUCTURE PROTECTION

• OCEANIA: Australia, New Zealand

• ASIA: China, India, Malaysia, Philippines, Thailand and Vietnam

• AFRICA: Congo, Madagascar, South Africa

• AMERICA: Chile, Colombia, El Salvador, USA, Venezuela
VETIVER SYSTEM FOR INFRASTRUCTURE PROTECTION IN OCEANIA

• Australia
• New Zealand
Tropical Northern Australia

Railway line

Very steep road culvert
Tropical Northern Australia

Road shoulder protection

Table drain protection
Southern Australia

Bridge abutment protection
New Zealand: North Island

Residential Site

Cliff face
VETIVER SYSTEM FOR INFRASTRUCTURE PROTECTION IN ASIA

- China
- Hong Kong
- India
- Indonesia
- Malaysia
- Philippines
- Thailand
- Vietnam
CHINA – Fujian: Newly planted batter on highway

PC: L Xu
CHINA: Fuzhou

PC: L Xu

CHINA: Guangdong

PC: H Xia
Summary of progress of VS application: First and second month

Stage of greening a newly treated slope
Summary of progress of VS application: Third and fourth month

Stage of greening a newly treated slope
India (North East): Assam

The site before and after vetiver planting at Noonmati

PC: Shantanoo
India (North East): Brahmaputra River, Assam

PC: Shantanoo
Indonesia: IRE research site Bandung-Nagreb Road
Small Scale Laboratory Experiments at Indonesian Institute of Road Engineering (IRE) 
Asep Sunandar and Nanny Kusminingrum

Soil Type: Dusty Clay, Stability Index: Unstable, 3 Month Old, West Java

Soil Type: Silty Clay Loam, Stability Index: Unstable, 3 Month Old, West Java

Soil Type: Dusty Clay, Stability Index: Unstable, 3 Month Old, West Java
Small Scale Laboratory Experiments
At Indonesian Institute of Road Engineering (IRE)
Asep Sunandar and Nanny Kusminingrum

Soil Type: Clay Loam, Stability Index: Stable, 4 Month Old, Nagreg West Java

Slope 80°, Age: 4 months
Before trimming

Slope 80°, Age: 4 months
After trimming
Indonesian Institute of Road Engineering (IRE)
Trial comparing 3 Vetiver planting densities, Bahia grass and bare slope at Nagreg West Java
Bahia grass

Vetiver

Vetiver planted at 3 densities
Very steep, 80° slope on highly erodible red volcanic soil
MALAYSIA - East West Highway: Vetiver planting to protect a very steep culvert outlet

PC: Diti Hangchaovanhich
A very high cut slope

Vetiver on upper part

Conventional measures on lower part

PC: Diti Hangchaovanich
MAIBARARA GEOTHERMAL POWERPLANT
Sto. Tomas Batangas, Philippines

- 10 Vetiver plants per linear meter
- .5 meter distance between rows (10 meters from the top)
- 1.5 meter distance between rows (lower part of slope)
- "ornamental peanut plants" planted in between rows

MAY 10, 2013

EROSION CONTROL AND REVEGETATION ON CUT SLOPE

MAY 31, 2013
THAILAND - Kanchanaburi, Highway 3272

*Arachis pintoi*

PC: Surapol
VIETNAM

Ho Chi Minh Highway

This highway is more than 3 000km long, stretching over the whole length of Vietnam, from the Chinese border in the north to the gulf of Thailand in the south. It runs over skeletal mountainous soils and cold winter in the North and central Vietnam to alluvial and extremely acidic sulfate soil and hot and humid climate in the South. All of which are highly erodible and unstable in the monsoon and cyclone seasons.

Vetiver planting is the main method of stabilisation of deep cut and high fill slope, and landslip mitigation.

This is probably the largest application of Vetiver System for infrastructure protection in the world

Due to its success the Ministry of Transport, recommend Vetiver System Technology for slope stabilization along all the national and provincial roads.
Widespread landslides during construction

PC: Van Tran
Traditional rigid structures are very expensive to build and maintain.

- Collapsed wall
- Soil Nailing
- Concrete wall
- Gabion
- Collapsed gabion
These barriers are useless in containing the mud flow.
Vetiver is effective low cost to build and maintain
With Vetiver

No Vetiver
VETIVER SYSTEM FOR INFRASTRUCTURE PROTECTION IN AFRICA

• Congo
• Guinea
• Madagascar
• South Africa
Two months after planting
Two weeks after planting

CONGO KINSHASA:
Vetiver planting for erosion control and deep cut and high fill slope stabilisation

PC: A Ndona
Very good growth and establishment 11 weeks after planting
Protecting steep culvert head
Planting in November 2012

4 months after planting
Vetiver was trimmed back to 40-50cm high to encourage tillering
Vetiver was trimmed back and shoots use as mulch on inter row space.
GUINEA (West Africa): Road Batter

Still stable after 8 years
MADAGASCAR – Vetiver planting for erosion control on road and railway batters

PC: Y Coppin
25,000 Vetiver were planted in August 2013, total 2.500m in length, with a spacing of 0.60m between the rows.
SOUTH AFRICA

Sand dune stabilisation
VETIVER SYSTEM FOR INFRASTRUCTURE PROTECTION IN THE AMERICAS

- California
- Brazil
- Chile
- Colombia
- Ecuador
- El Salvador
- Venezuela
CALIFORNIA
Batter stabilization
BRAZIL: Road Batters

PC: Paula Pereira
BRAZIL: Road Batters

PC: Paula Pereira
Chile : Bio Bio Riverbank Batters
COLOMBIA: Soil Nails and Vetiver
Eco Mortar
Is a weak shotcrete, (a mixture of cement, soil and fiber). Eco Mortar was developed and used extensive in Colombia by MECETA.
COLOMBIA: Road Batters
Colombia: Road Batters using Ecomortar

PC: J Londono
Colombia: Road Batters using Ecomortar
Ecuador
Highway batters

PC: D Mascaro
El Salvador
Highway batters
GUATEMALA: 72 degree batters, Vetiver and geofabrics

PC: L Castro
Batters on 72 degree slope with geofabrics

May 2012

June 2012

PC: L Castro
Very steep batters with geofabrics
Venezuela: Road Batters

PC: R Luque
Venezuela: Road Batters

PC: R Luque
Venezuela: Landslide
**PRINCIPLES FOR SUCCESSFUL SLOPES STABILISATION WITH VETIVER GRASS**

1. **Appropriate designs and techniques**
The slope has to be designed and constructed to the standard that it is structurally and sustainably stable on its own right. In general, VS will protect the slope from shallow slips by providing structural and hydraulic improvement of soil profile down to its root depth.

2. **Proper Implementation**
   - Timing, to make the most of rainfall and to avoid or reduce the impact of extreme weather
   - Planting material quality and availability are extremely important
   - Adequate fertilisation and weed control
   - Adequate Staff training

3. **Vigorous maintenance program**
Similar to hard engineering structures, bioengineering structure has to be properly maintained to ensure its sustainability.
ADVANTAGES AND DISADVANTAGES OF THE VETIVER SYSTEM

Advantages
• The major advantage of VS is its low cost. Saving 65% and 75% in Australia for various structures and 90 to 85% in China and in low labour cost countries
• VS provides a natural, green and environment friendly method of erosion control and land
• Low maintenance costs in the long term.

Disadvantages
• The main disadvantage of the VS applications is the time lag between implementation and full effectiveness,
• Intolerance to shading, partial shading will reduce growth hence it is not suitable for fully shaded areas
CONCLUSION

Success and effectiveness of the Vetiver System technology in steep slope stabilization depends largely on:

- Appropriate design
- High quality planting materials
- Good planting techniques
- Appropriate maintenance
- Planting time

*Experience has shown that failures of the Vetiver System Technology in infrastructure protection are most likely due to bad design, improper implementation and inadequate maintenance rather the technology itself.*
This shows despite the bad design, vetiver was still able to stabilise this cut batter due to proper implementation, good quality planting material and favourable weather conditions.