Global Review on the Application of Vetiver System for Infrastructure Protection

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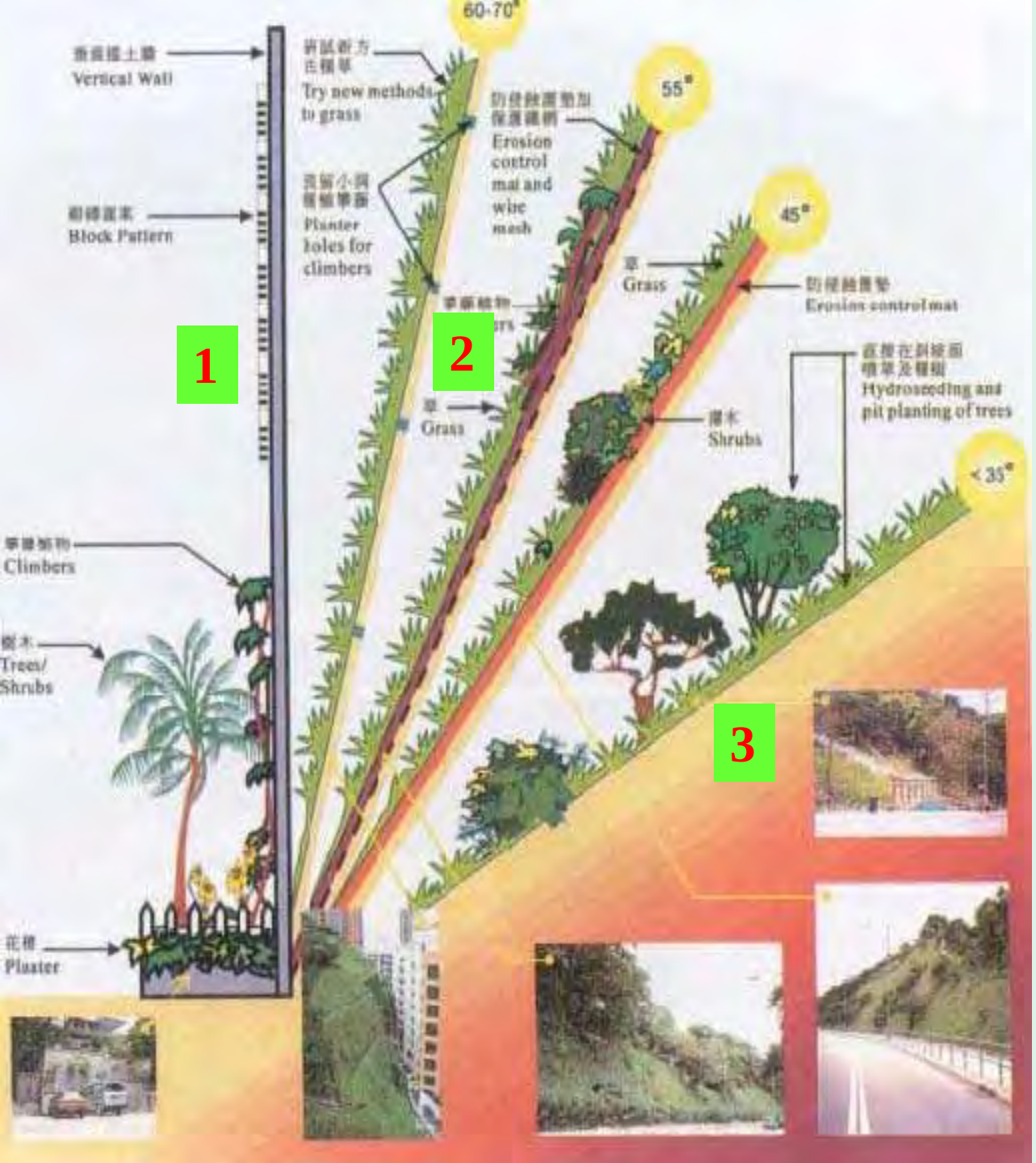
Common Types of Slope Instability

1. **Surficial erosion**
2. **Shallow mass movement**
3. **Slides, slips, deep-seated mass movement, failure**

DYNAMIC roots function in topsoil = erosion control

?

Deep Roots penetrate subsoil = PASSIVE anchorage / soil reinforcement



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^{o}C to 55^{o}C.**

Deep, penetrating and high shear strength root system

3m deep on a fill batter in Malaysia

Penetrating roots through compacted earth

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

A mixture of cement, sand and cellulose

Sand bags

A combination of concrete drains and vetiver are used to stabilise this very steep and highly erodible batter in Thailand

PC: Man Tran

Very high and steep slope in Vietnam

Without Vetiver reinforcement, concrete blocks by themselves could not protect slope in long term

PC: Man Tran

Vetiver used in combination with oncrete 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

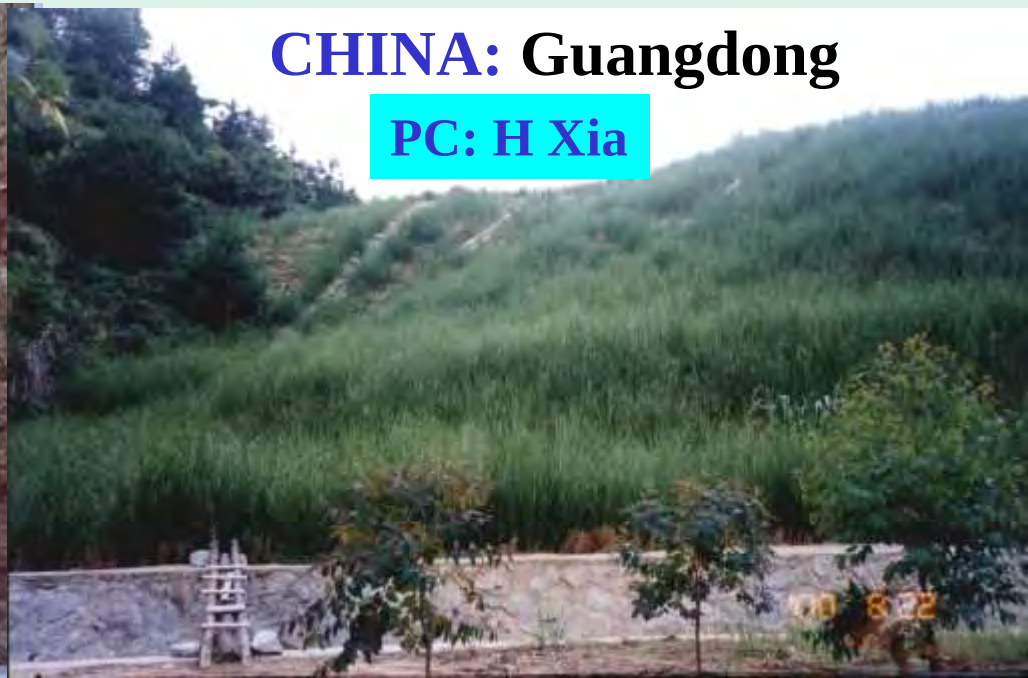
PC: L Xu

CHINA: Fuzhou

PC: L Xu

CHINA: Guangdong

PC: H Xia



HONGKONG

PC: PK Yoon

Summary of progress of VS application: First and second month

Summary of progress of VS application: Third and fourth month

Stage of greening a newly treated slope

3rd month

4th month

India (North East): Assam

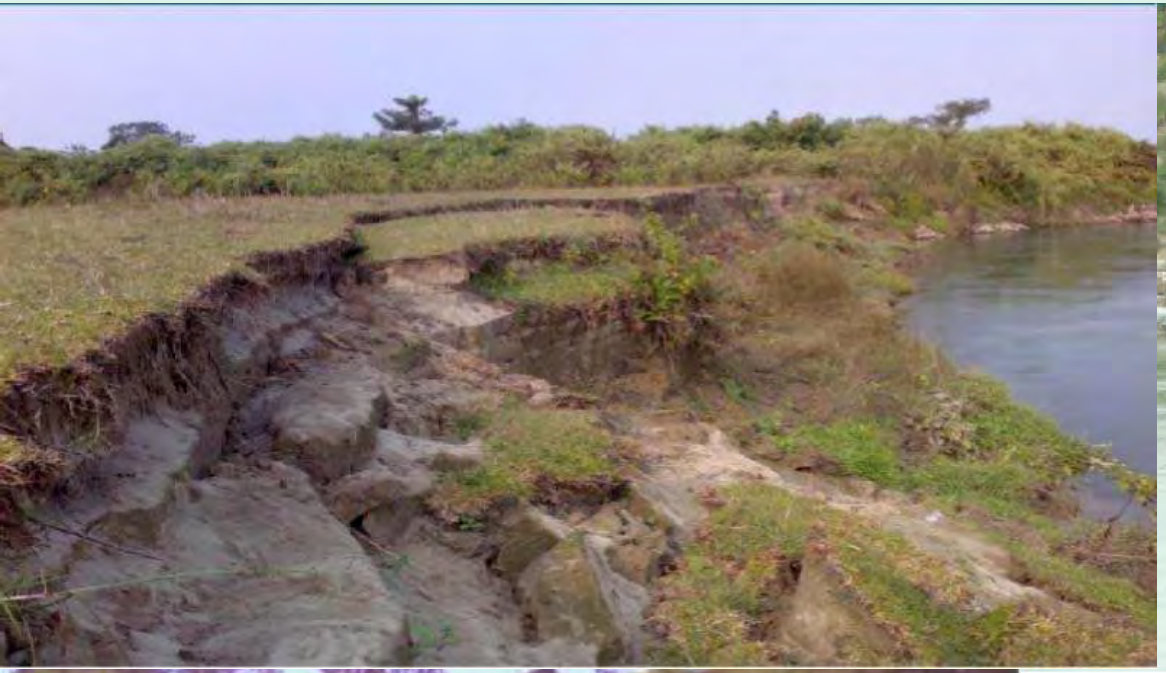
PC: Shantanoo

The site before and after vetiver planting at Noonmati

No vetiver

Vetiver Planting

India (North East): Brahamaputra 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: 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 Hangchaovanich

A very high cut slope

PC: Diti Hangchaovanich

PHILIPPINES - Central Luzon Highway

PC: N Manarang

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

MAY 31, 2013

EROSION CONTROL AND REVEGETATION ON CUT SLOPE

VETIVER FARMS

THAILAND - Kanchanaburi, Highway 3272

PC: Surapol

Arachis pintoi

PC: Van Tran

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.

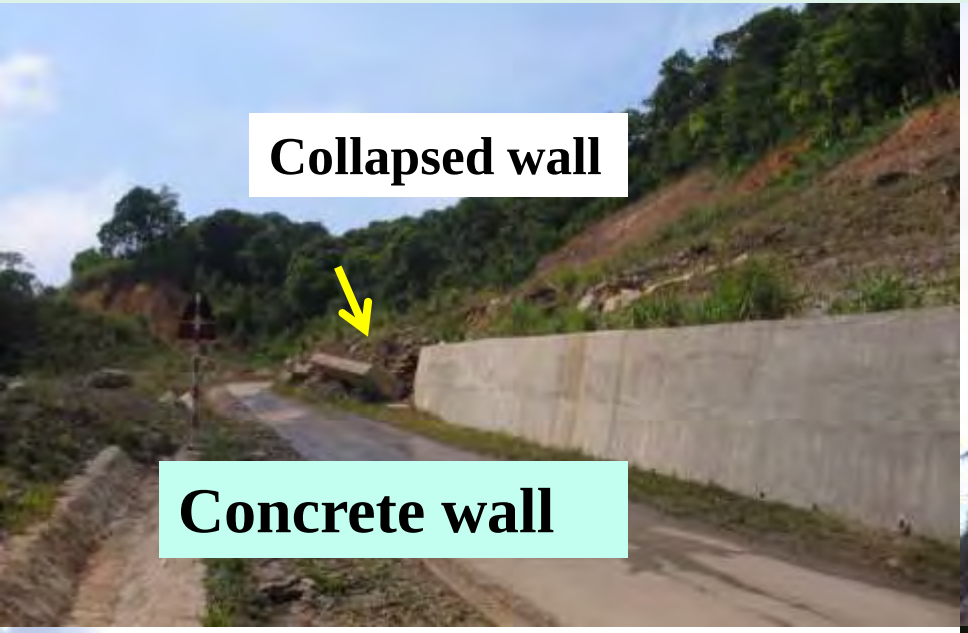
This is probably the largest application of Vetiver System for infrastructure protection in the world

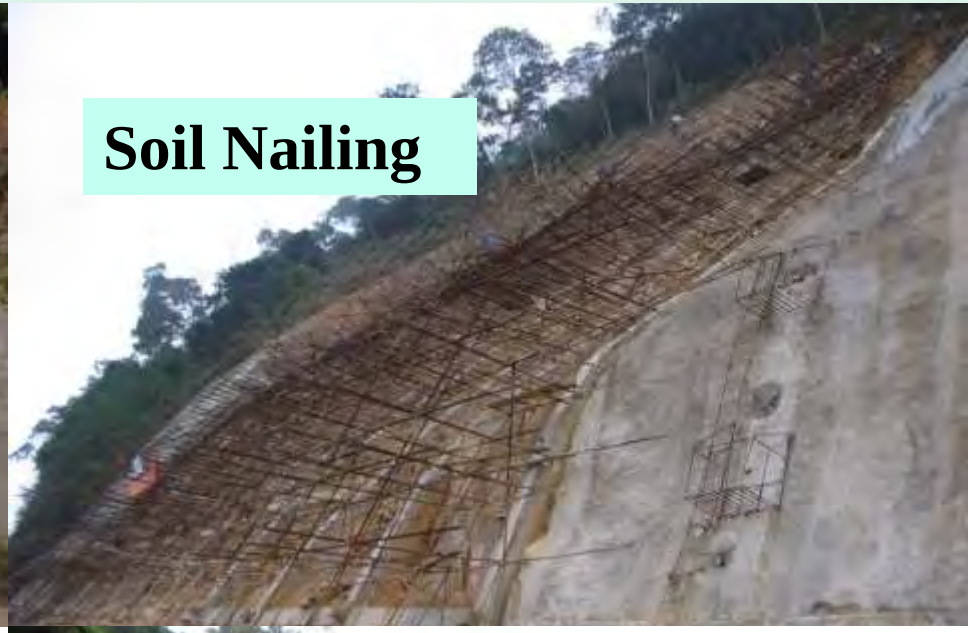
Due to its success the Ministry of Transport, recommend Vetiver System Technology for slope stabilization along all the national and provincial roads.

PC: Van Tran

Widespread landslides during construction

Traditional rigid structures are very expensive to build and maintain





These barriers are useless in containing the mud flow

THE VETIVER SYSTEM SOLUTION

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**

CONGO, KINSHASA

PC: A Ndona

Two months after planting

PC: A Ndona

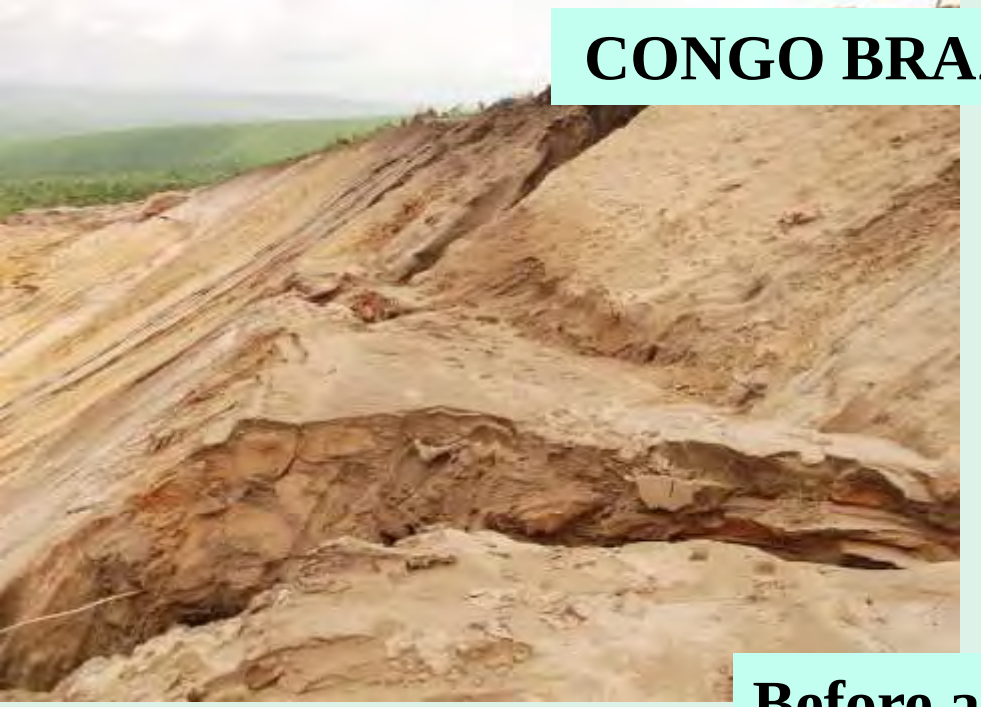
CONGO KINSHASA :

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

Two weeks after planting

CONGO BRAZZAVILLE

PC: A Ndona



Before and after

Very good growth and establishment 11 weeks after planting

Protecting steep culvert head

Drainage line protection

Planting in November 2012

PC: A Ndona

4 months after planting

May 2013

5 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

PC: A Ndona

GUINEA (West Africa): Road Batter

PC:R Noffke

Still stable after 8 years

MADAGASCAR –Vetiver planting for erosion control on road and railway batters

PC: Y Coppin


27/05/2010


28/05/2010

PC: Y Coppin

MADAGASCAR:

Railway between Tananarive and Tamatave

25.000 Vetiver were planted in August 2013, total 2.500m in length, with a spacing of 0.60m between the rows.

SOUTH AFRICA

PC: R Noffke

Sand dune stabilisation

VETIVER SYSTEM FOR INFRASTRUCTURE PROTECTION IN THE AMERICAS

- **California**
- **Brazil**
- **Chile,**
- **Colombia**
- **Ecuador**
- **El Salvador**
- **Venezuela**

PC: D Richardson

CALIFORNIA

Batter stabilization

CALIFORNIA

Batter stabilization

BRAZIL: Road Batters

PC: Paula Pereira

BRAZIL: Road Batters

PC: Paula Pereira

PC: Paula Pereira

Chile : Bio Bio Riverbank Batters

COLOMBIA: Soil Nails and Vetiver

PC: D Londono

COLOMBIA: Road Batters

PC: J Londono

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

PC: J Londono

Colombia:
Road Batters using Ecomortar

Colombia: Road Batters using Ecomortar

PC: D Mascaro

Ecuador

Highway batters

El Salvador

Highway batters

GUATEMALA: 72 degree batters, Vetiver and geofabrics

PC: L Castro

PC: L Castro

Batters on 72 degree slope with geofabrics

May 2012

June 2012

Very steep batters with geofabrics

Venezuela: Road Batters

PC: R Luque

Venezuela: Road Batters

PC: R Luque

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

Thank You