EXTREME SLOPE STABILISATION WITH VETIVER SYSTEM (Front Cover)

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INTRODUCTION

The important role of Vetiver System Technology in Bioengineering has been well established. It has also been observed that Vetiver is very effective in stabilising extreme slopes.

This booklet will explain/demonstrate how Geotropism (also known as Gravitropism) plays an important role in this stabilisation process.

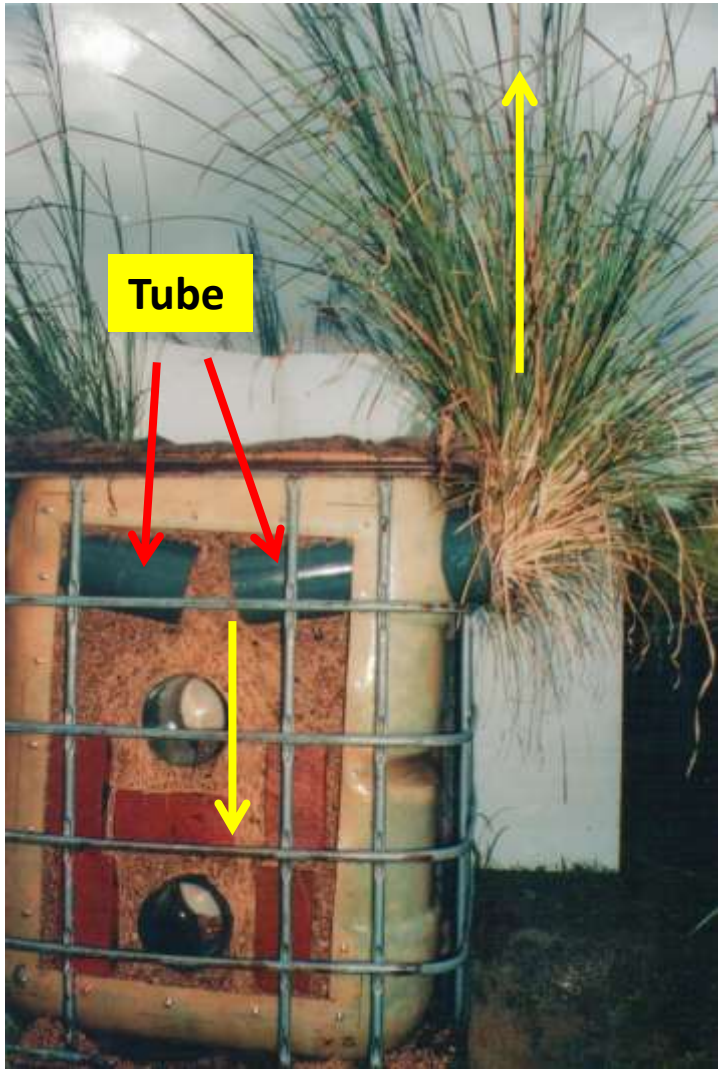
Geotropism is a growth movement by plants in response to gravity . Charles Darwin was one of the first to scientifically documented that:

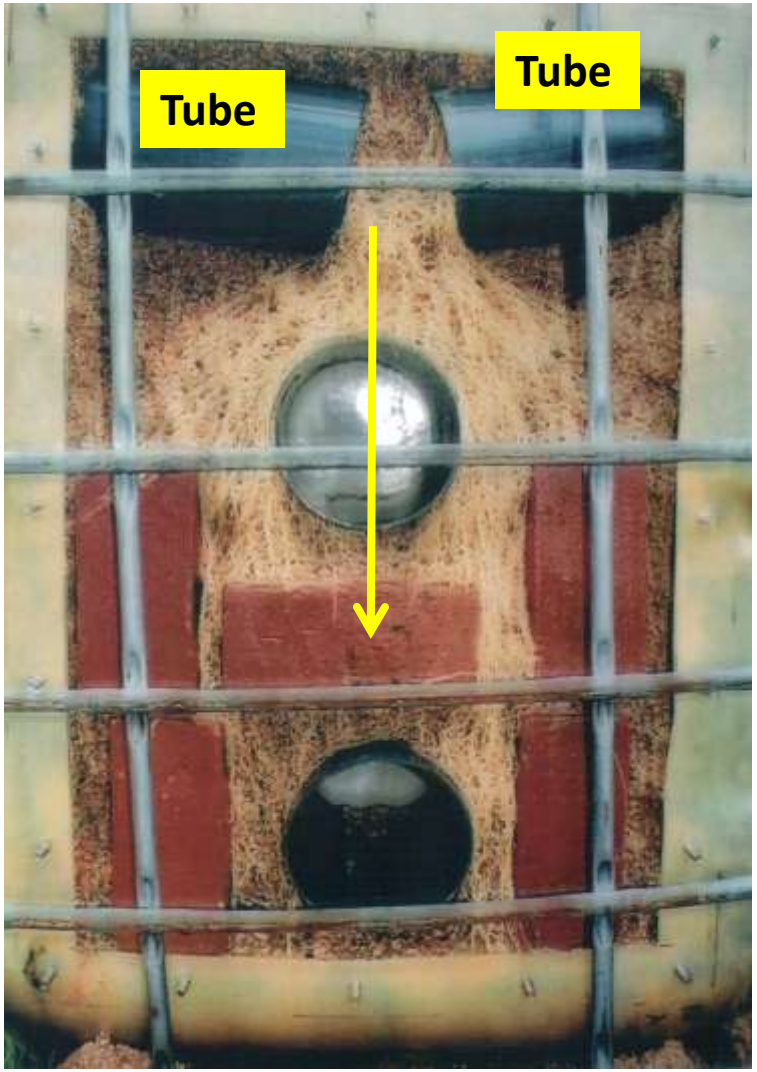
- ***Plant roots have Positive Geotropism: roots always grow down***
- ***Plant shoots have Negative Geotropism: shoots always grow up***

In a series of trials, Dr. P K Yoon of Malaysia, a founding Director of The Vetiver Network International (TVNI), clearly showed geotropism strongly affected vetiver growth and development

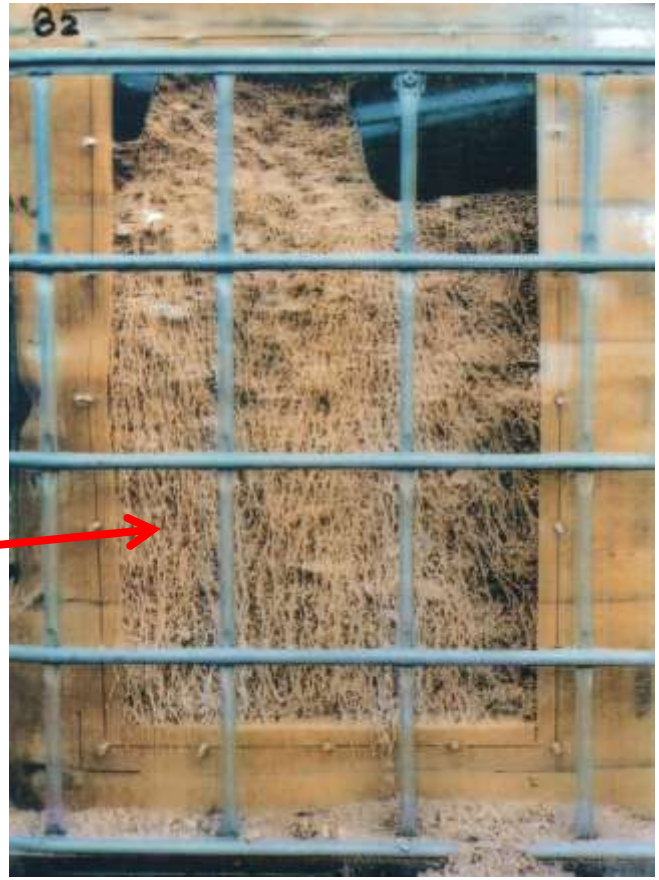
Vetiver Geotropism Research Conducted by Dr. PK Yoon

Vetiver was planted almost horizontally through these tube. While the roots grow down and the shoots grow upwards





The combination of Vetiver extensive roots and its positive geotropism creates a solid and stable protective cover on soil surface below the plant when it is planted on extreme slopes



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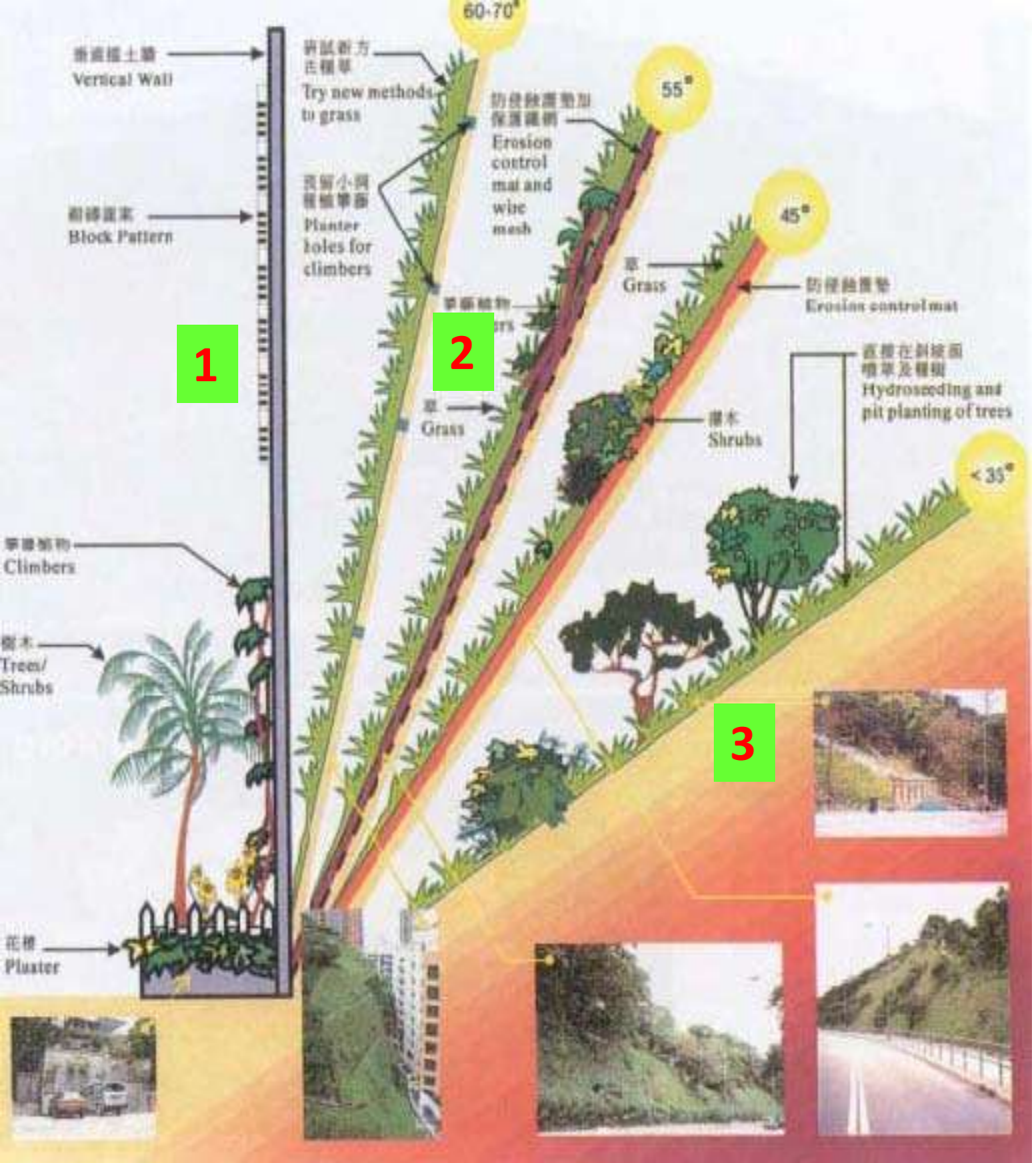
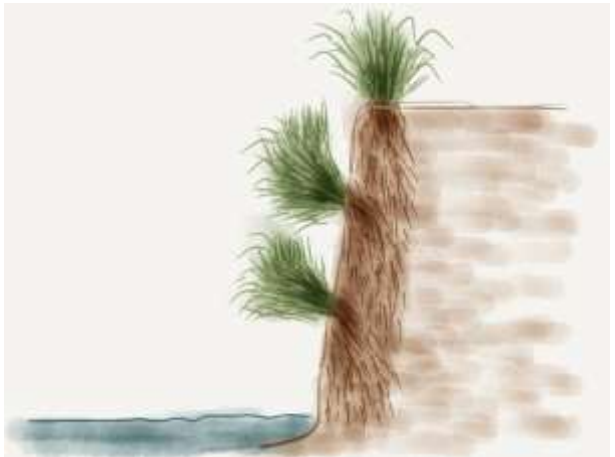
These pots fell on its side in the nursery. Note the roots on the bottom of the pot grew out the hole and downward, those roots that cannot get through the holes forced its way sideward and down

Options for Slope Protection:

1. Hard structures
2. Combination of hard and soft bioengineering including geofabrics
3. Bioengineering alone including geofabrics on erodible soil

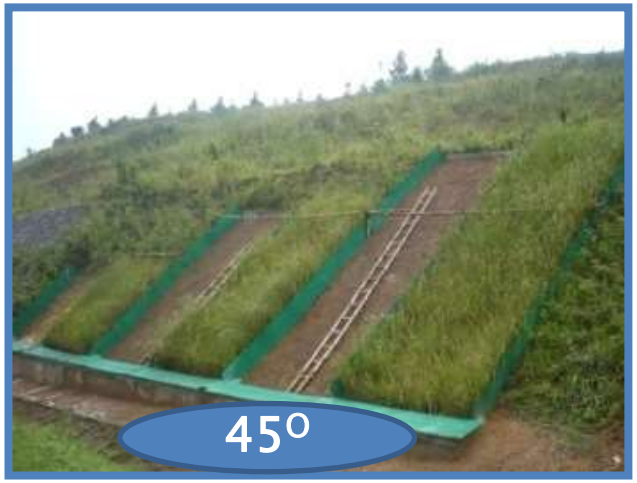




Asep Sunandar and Nanny Kusminingrum

Indonesian Institute of Road Engineering (IRE) conducted a series of experiments with slopes ranging from 30o to 80o

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

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

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Indonesian Institute of Road Engineering (IRE)

Trial comparing 3 Vetiver planting densities, Bahia grass and bare slope at Nagreg West Java

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Very steep, 80^{o} slope on highly erodible red volcanic soil

Small Scale Laboratory Experiments At Indonesian Institute of Road Engineering (IRE)

Asep Sunandar and Nanny Kusminingrum

CONCLUSION

- **Vetiver system can be used effectively to control surface erosion and shallow failure of road slope**
- **Vetiver system can be used effectively at slope between 30^{o} – 60^{o}**
- **Vetiver system could be applied by road authorities to cope with erosion and shallow failure of road slope**
- **At road slope >60^{o}, vetiver technology is not recommended to be applied solely (must combined with geotextiles and/or mechanical methods)**

Based on the above technical data, vetiver system has been used very effectively in stabilising extreme and highly erodible slopes around the world

The following photos show successful applications of VS on extreme slopes:

- **Without Geofabrics and No Hard Structure**
- **With Geofabrics**
- **With Hard Structures**

Without Geofabrics: AUSTRALIA, Brisbane

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This is a very steep sandy riverbank, holes were made with special tools

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PC PL Pereira

Without Geofabrics : BRAZIL Road Batters

Without Geofabrics : CHINA Zhejiang Province

National Highway 330 on slope area of 10 600m2 to prevent landslides

PC D Londono

Without Geofabrics : COLOMBIA Road Batters

PC P Truong

Without Geofabrics

COLOMBIA

Construction site

PC P Truong

Without Geofabrics

COLOMBIA

Construction site

PC P Truong

Without Geofabrics

COLOMBIA

Construction site

Without Geofabrics : HONGKONG Road Batters

PC PK Yoon


Sin Tin Wai Estate
Feature No. 7SW-D/C1


CED Contract No. GE/2000/04
Landslip Preventive Works for Slopes and Retaining Walls
in Tsuen Wan and Kwai Tsing Districts
Feature No. 7SW-C/C47 at Kwai Shing Circuit
11.5 MONTHS
11 MONTHS
8.5 MONTHS
8 MONTHS
25 JUN 2002

Without Geofabrics : INDONESIA East Java

PC A Sunandar

Before

1 month

2.5 months

4 months

Slope length: 300m, height: 14 m,

Regular trimmings after 4 month

PC D Booth

Without Geofabrics : INDONESIA Bali

Steep land before planting Vetiver

Planting vetiver using long ladders

Vetiver growth after 1 month

4 months after planting

PC D Booth

Without Geofabrics : INDONESIA Bali

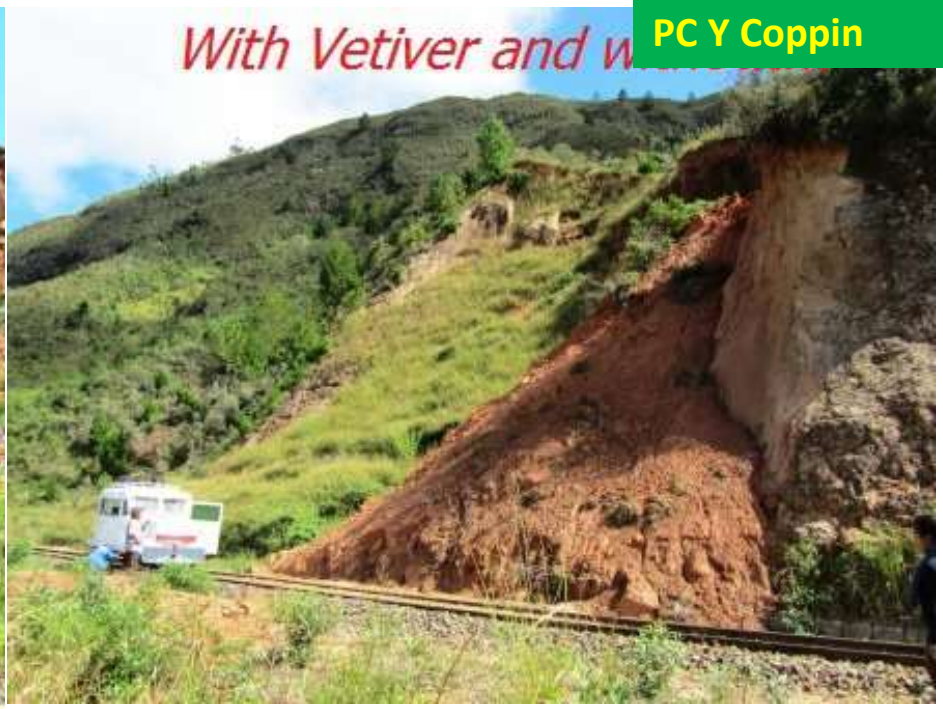
Without Geofabrics : INDIA Assam, Doria Bridge

PC S Bhattacharyya

Without Geofabrics : MADAGASCAR Lavaka

PC Y Coppin

PC Y Coppin



PC Y Coppin

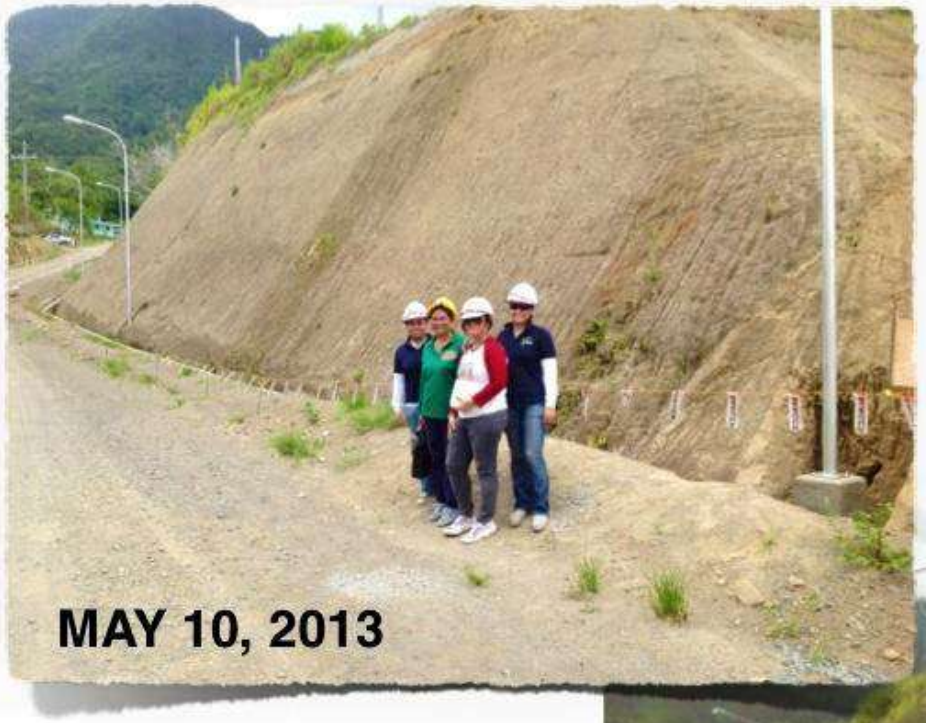
Without Geofabrics : MADAGASCAR Railway Batters

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.

Without Geofabrics : PHILIPPINES Central Luzon Highway



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

PC N Manarang

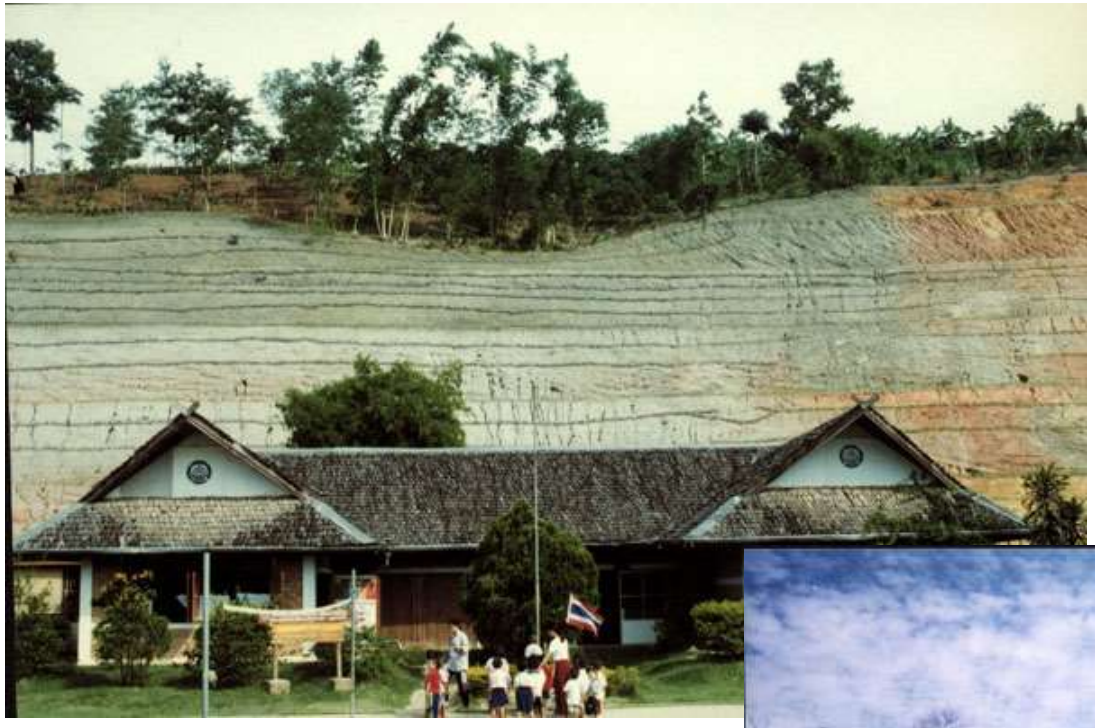
EROSION CONTROL AND REVEGETATION ON CUT SLOPE

VETIVER FARMS

Without Geofabrics : THAILAND Central Highlands

PC S Sanguankaeo

Without Geofabrics : THAILAND Chiang Rai



Landslide: Before and After

Landslide: Before and After

Without Geofabrics : USA, Hawaii Island

PC J Fox


PC J Fox

Without Geofabrics : VENEZUELA Road Batters

PC R Luque

Without Geofabrics : VENEZUELA Landslide

PC R Luque

Without Geofabrics : VIETNAM Ho Chi Minh Highway

PC P Truong

PC P Truong

Ho Chi Minh Highway – Central Vietnam

PC P Truong

Ho Chi Minh Highway
Central Vietnam

Without Geofabrics : VIETNAM Da Nang

PC M Tran

With Geofabrics : AUSTRALIA Brisbane

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Highly erodible sandy soil with gradient up to 50o at some sections

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Laying Geofbrics

PC P Truong

Vetiver planting

Six months after planting

With Geofabrics : BRAZIL Road Batters

PC PL Pereira

PC PL Pereira

With Geofabrics : GUATEMALA: Batters on 72 degree slope using 3D geofabrics

PC L Castro

PC L Castro

Batters on 72 degree slope with geofabrics

May 2012

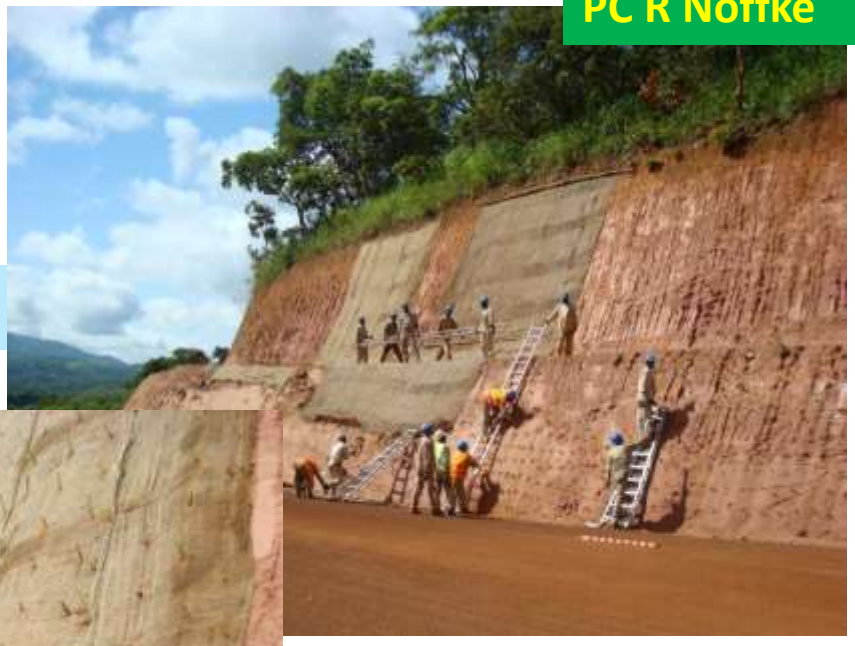
June 2012

PC L Castro

Very steep Batters with geofabrics

With Geofabrics : GUINEA (West Africa): Road Batters

PC R Noffke



Still stable after 8 years

PC R Noffke

With Geofabrics: DCR CONGO Road Batters

PC R Noffke

On 60°-70° vertical slope using Green TerraMesh walls at Selembao Kinshasa.

With Sand Bags:

BRAZAVILLE CONGO

Urban ravine rehabilitation

PC A Ndona

Sand Bags

Bags can be filled with sand, soil and fertilizer or a mixture of sand and soil where local soil is poor or rocky.

BRAZZAVILLE CONGO

Vetiver is planted into the bags with soil and fertilizers

BRAZZAVILLE CONGO

PC A Ndona

Excellent Vetiver growth and ravine stabilized

With Eco-Mortar: 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 .

PC J Londono

COLOMBIA:
Road Batters

PC J Londono

COLOMBIA: Landslide

Completely cover the whole slope with vetiver plants

PC J Londono

COLOMBIA:
Landslide

PC J Londono

COLOMBIA: Landslide

COLOMBIA

Excellent establishment due to erosion control, moisture and fertilizer retention of Ecomortar

PC J Londono

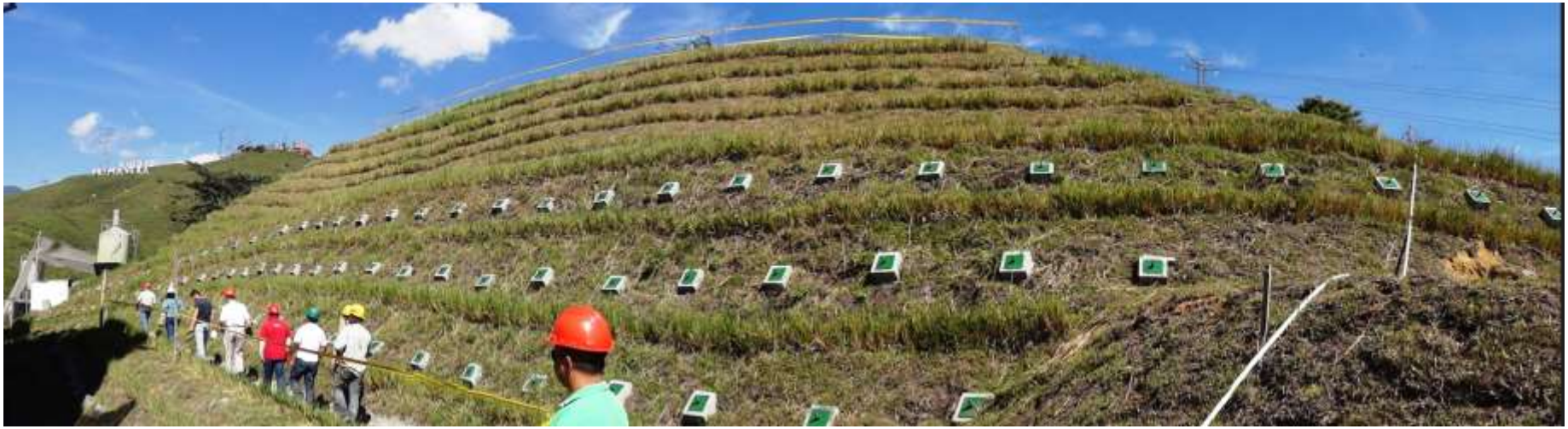
With Soil Nails: COLOMBIA: Medellin

PC D Londono

PC D Londono

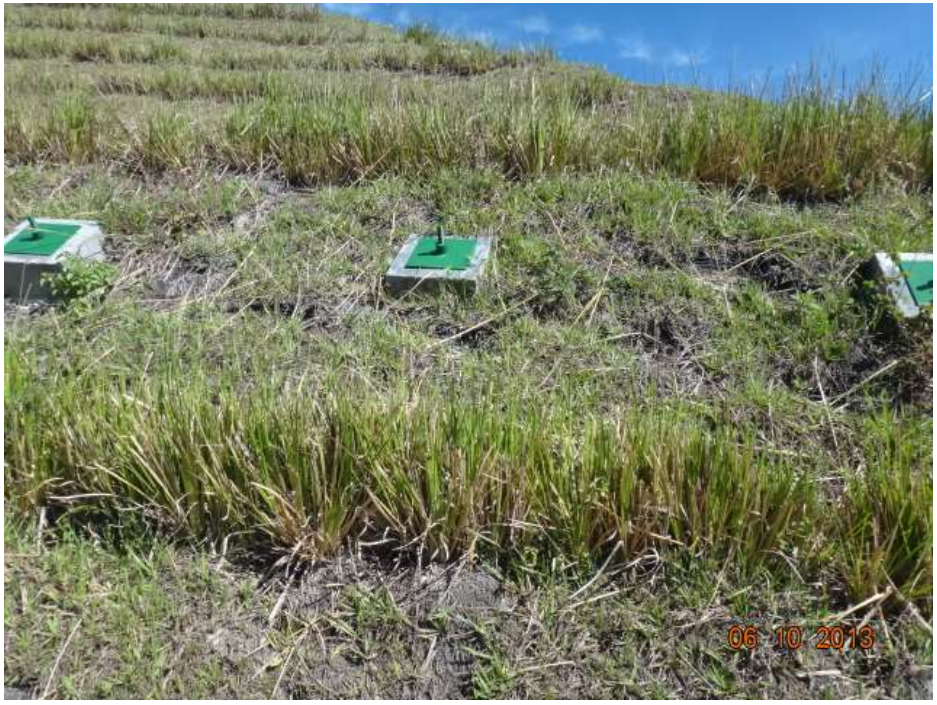
With Soil Nails: COLOMBIA: Medellin

PC P Truong



Ten months after planting

PC P Truong



PC P Truong

With Soil Nails: VIETNAM Da Nang

PC V Nguyen

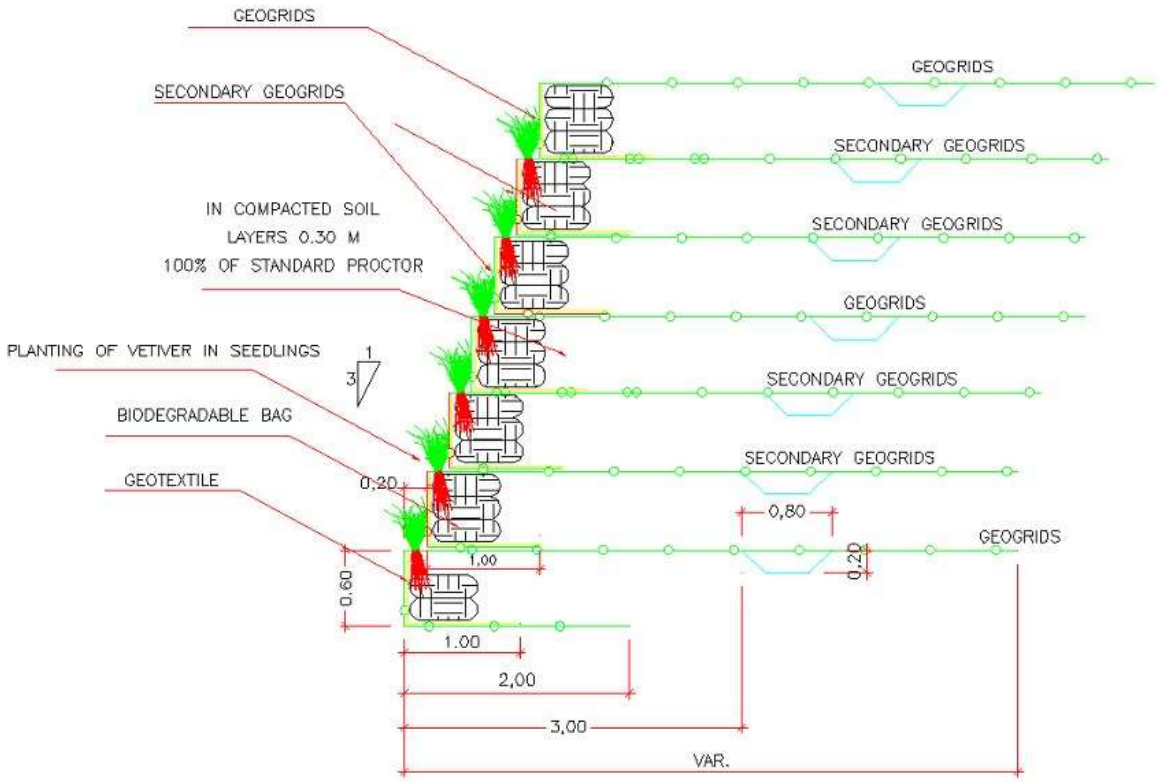
PC V Nguyen

With Geogrids: BRAZIL Sao Paolo

PC F Andrade

This is the work performed on in an environmental protected area with approximately 1100 m² of front and 25 meters tall.

The technique consists the formation of containment systems using geogrids, soil and Vetiver. The roots of vetiver play a fundamental role for the success of the wall, because its depth and its generous amount of root aggregated to the soil. This very deep roots' system, and rapid growth also makes vetiver very drought tolerant and highly suitable for stabilizing the wall.



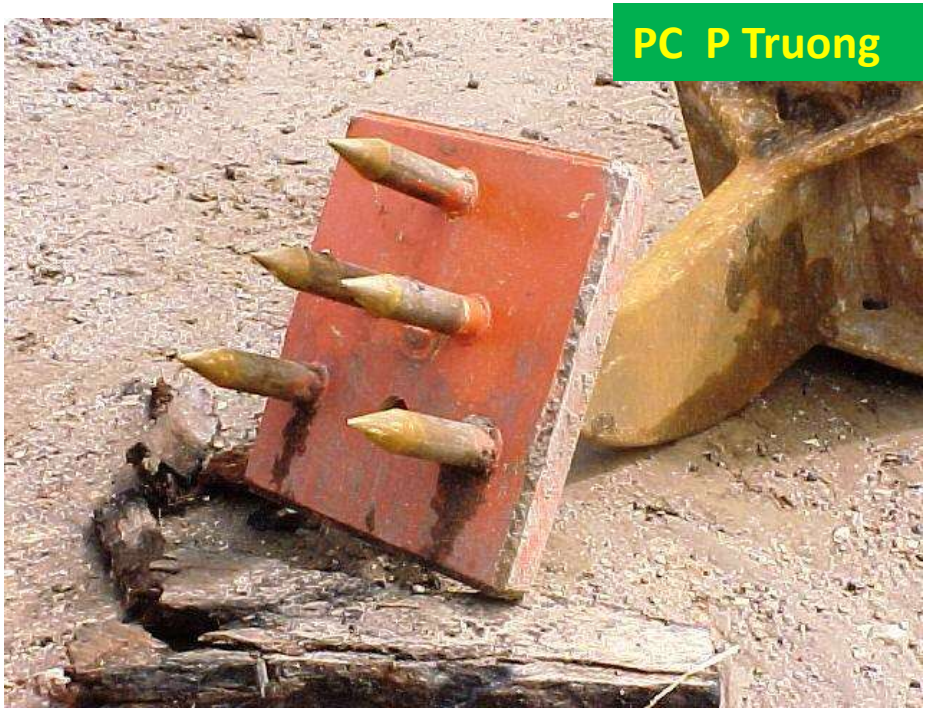
PC F Andrade

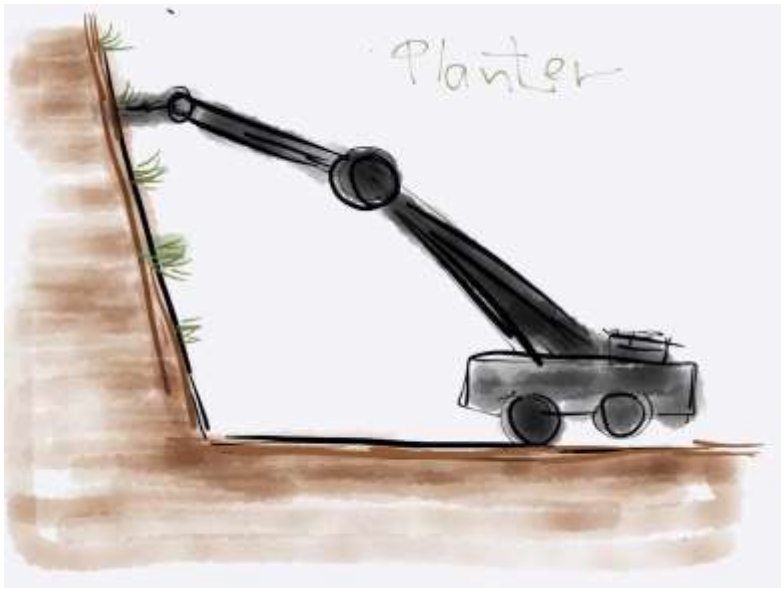
PC F Andrade

Two years later

Some Instruments Used on these Extreme Slopes

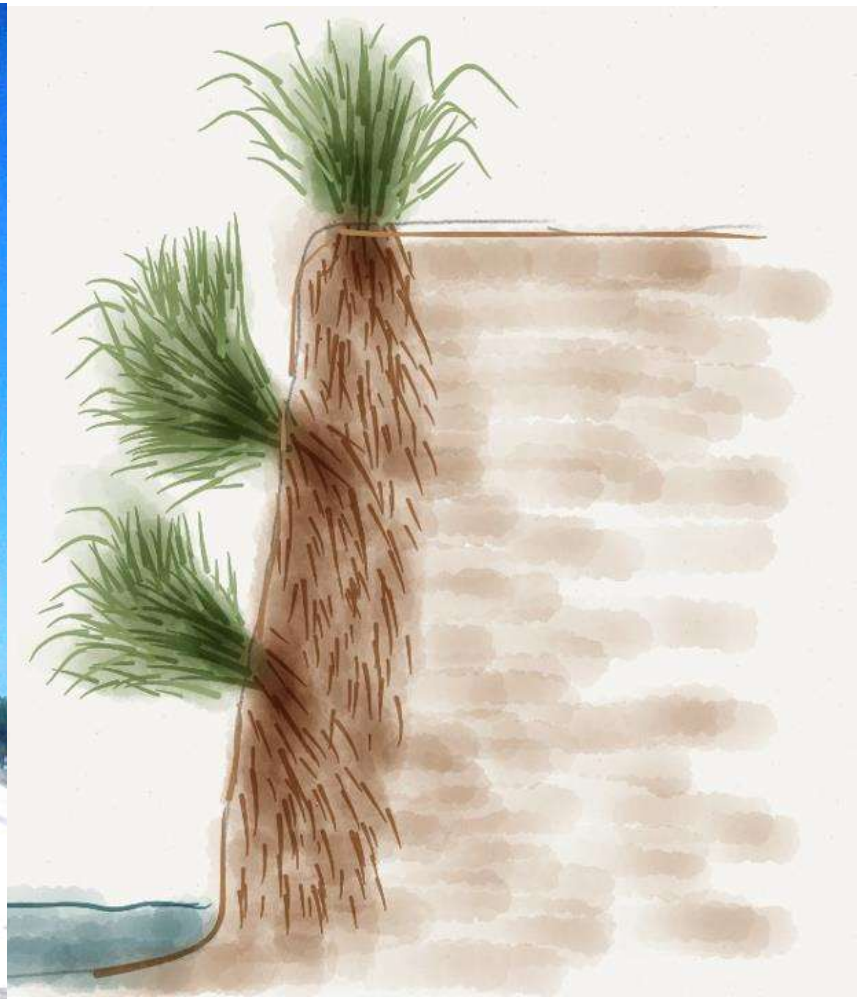
This Australian "Hole puncher" is mounted on a backhoe to make holes for vetiver planting on the steep wall





Ladder, Portable Drill and Strong Hands in GUINEA (West Africa)

PC R Noffke



INCREDIBLE
GO FOR IT!