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

Paul Truong
Director, The Vetiver Network International,
Veticon Consulting, Brisbane, Australia.
<truong@uqconnect.net>
Special Characteristics of Vetiver Grass Suitable for Slope Stabilization

Tall Erect and stiff stems, forming a thick hedge when planted in row
Deep, extensive and penetrating root system

- Although classified as a grass, for land stabilization purposes, Vetiver plants behave more like fast growing trees or shrubs. Per unit area Vetiver roots are stronger than tree roots.

- Extremely deep and massive finely structured root system, capable of reaching down to 2 to 3m in the first year. Many experiments show Vetiver grass can reach 3.6m in the first 12 months on fill slope.

- This extensive and thick root system binds the soil and at the same time makes it very difficult to be dislodged and extremely tolerant to drought.

- Vetiver roots can penetrate compacted soil profile such as hardpan and blocky clay pan common in tropical soils, providing a good anchor for fill and topsoil.
Deep, extensive and penetrating root system

One year old: 3.3m deep
Vetiver zizanioides

Outside the box

Vetiver nemoralis
Strong root reinforcement holding up this wall of soil against water erosion
Extensive root distribution at depth
Mechanical Characteristics

Tensile strength of vetiver roots

- Tensile strength increases with reduction in root diameter, i.e. stronger fine roots provide higher resistance than larger roots.
- Tensile strength of vetiver roots varies between 40-180 MPa for the range of root diameter between 0.2-2.2 mm.

- Mean design tensile strength is 75 MPa (appr. 1/6 of mild steel) at 0.7-0.8 mm root diameter - the most common size of vetiver roots.
- This indicates vetiver roots are as strong as, even stronger than many hardwood species (Hengchaovanich and Nilaweera, 1996).
Mechanical Characteristics

Shear strength of vetiver roots

- Soil block shear test also showed that root penetration of a two year old Vetiver hedge with 15 cm plant spacing can increase the shear strength of soil in adjacent 50 cm wide strip by 90% at 0.25 m depth. The increase was 39% at 0.50 m depth and gradually reduced to 12.5% at 1.0 m depth.

Moreover, because of dense and massive root system it offers better shear strength increase per unit fiber concentration (6-10 kPa/kg of root per cubic meter of soil) compared to 3.2-3.7 kPa/kg for tree roots (Hengchaovanich and Nilaweera, 1996).
Shear test of vetiver roots
Hydraulic Characteristics

- When planted in rows Vetiver plants will form thick hedges and with their stiff stems can stand up to at least 0.6-0.8m, forming a living barrier which slows and spreads runoff water. If properly laid out, these hedges can act as very effective diversion structures spreading and diverting runoff water to stable areas or proper drains for safe disposal.

- Hydraulic characteristics of Vetiver hedges under deep flows were determined by flume tests at University of Southern Queensland for the design and incorporation of Vetiver hedges into strip cropping layout for flood mitigation. The hedges were successful in reducing flood velocity and limiting soil movement, resulting in very little erosion in fallow strips and a young sorghum crop was completely protected from flood damage (Dalton et al, 1996).
Hydraulic Characteristics

Where: $q =$ discharge per unit width; $y =$ depth of flow; $y_1 =$ depth upstream; $S_o =$ land slope; $S_f =$ energy slope; $N_F =$ the Froude number of flow.

Hydraulic Model of Flooding through Vetiver Hedges
(P Dalton, 1998)

Figure 1: Hydraulic model of flooding through vetiver.
Fire tolerance

A very fierce bush fire swept through the area in October 2002

Vetiver row

Sediment trapped by the old row
Two weeks after fire
Five weeks after fire
Soil stabilisation mechanism by vetiver

Vetiver hedgerows

Vetiver roots

Slipping zone on slopes usually 0~2 m depths

Diti Hengchaovanich
Australian trial on a fill batter
One and half year after planting
After 400mm of rain in 10 days
After 400mm of rain in 10 days
Steep batter protected by vetiver hedges
Eight months after planting
Close up view of steep batter protected by vetiver hedges
Eight months after planting
Bridge abutment stabilisation
Ten weeks after planting
### Cost Summaries

<table>
<thead>
<tr>
<th>Road Batter Protection</th>
<th>AUD Per linear metre</th>
<th>AUD Per square metre of batter face</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vetiver hedges on Cut Batters</strong></td>
<td>18.40</td>
<td>21.40</td>
</tr>
<tr>
<td><strong>Vetiver hedges on Fill Batters</strong></td>
<td>15.50</td>
<td>18.20</td>
</tr>
</tbody>
</table>

**Culvert Protection**
- **Vetiver hedges** | 18.20
- **Grouted rock pitching** | 65.75

**Saving** | 73%

**Road Shoulder Protection**
- **Vetiver hedges** | 15.50
- **Traditional concrete shoulder dykes** | 38.00

**Saving** | 60%

**Table Drain Scour Protection**
- **Vetiver contour hedges** | 15.50
- **Traditional hard rock check dams** | 42.00

**Saving** | 64%

**Miscellaneous Protection Work**
- **Vetiver hedges generally** | 15.50
- **Steel wire rock mattress** | 43.00

**Saving** | 64%
HO CHI MINH HIGHWAY
Vietnam

A Learning Experience

• 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.

• It was badly designed and haltingly built by army engineers in 2002.

• Part of it is still unusable due to serious erosion and landslides during the wet season.
The original HCM Trail, started as a goat tract in 1956, then upgraded for bicycles and eventually for trucks and tanks in the 1970s. Now further widened for earth moving equipment. Mostly hidden then under a thick canopy of tropical rainforest.
Note the scars on the mountain side
Altogether it is more than 3000km long
Road Base ready for bitumen paving

Roads
Road Base ready for bitumen laying
Erosion soon after paving
Vetiver trial with good results
Implementation phase

On a 1.5H:1V gradient, 55m high cut slope
Implementation phase
Hoping for the best!
Same slope, one year after planting

Although not properly designed, this site remained stable 3 years after planting!
Three years after implementation
Three years after implementation

Vetiver
Before and After
THANK YOU