Application of Vetiver Grass Technology in the Stabilisation of Road Infrastructure in the Wet Tropical Region of Australia

(Presented at the International Vetiver Conference, Cha Am, Thailand, January 2000)

Nevil Bracken 1 and Paul Truong 2

1 Pavement Construction Management Pty Ltd and 2 Queensland Department of Natural Resources, Australia.
Location of work site
TYPICAL ROAD EMBANKMENT AND DRAINAGE PROBLEMS

HIGHLY ERODIBLE AND INFERTILE SOIL
Fragile and highly erodible
Severe erosion on unprotected cut slope
### Chemical Analyses of a Typically Poor Soil in the Wet Tropical Region of Australia

<table>
<thead>
<tr>
<th>Analyses</th>
<th>Units</th>
<th>Concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>7.3</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>dS/m</td>
<td>0.01</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/kg</td>
<td>Below quantification</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>mg/kg</td>
<td>Below quantification</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>mg/kg</td>
<td>4.0</td>
</tr>
<tr>
<td>Calcium</td>
<td>meq/100g</td>
<td>1.4</td>
</tr>
<tr>
<td>Magnesium</td>
<td>meq/100g</td>
<td>2.2</td>
</tr>
<tr>
<td>Sodium</td>
<td>meq/100g</td>
<td>0.04</td>
</tr>
<tr>
<td>Potassium</td>
<td>meq/100g</td>
<td>0.11</td>
</tr>
</tbody>
</table>
Typical example of highly erodible tropical soil of north Queensland
The soil is highly sodic and very infertile with little nutrients or organic matter.
TYPICAL ROAD EMBANKMENT AND DRAINAGE PROBLEMS

EROSION OF CUT BATTERS
Severe erosion on newly cut batter in the wet season
New batter, severely eroded within weeks in the wet season
Severe erosion on old batter
TYPICAL ROAD EMBANKMENT AND DRAINAGE PROBLEMS

EROSION OF FILL BATTERS
Badly eroded fill batter
If unprotected this road shoulder will be easily eroded by high intensity storms
Conventional concrete shoulder dykes are expensive and ineffective in protecting road shoulders on this highly erodible environment.
Hard rock protection are commonly used but it is also ineffective
Hard rock structures often failed due to undermining
TYPICAL ROAD EMBANKMENT AND DRAINAGE PROBLEMS

EROSION ON STEEP BATTERS AT CULVERTS INLETS AND OUTLETS
Steep batter at culvert outlets is highly erodible
Highly erodible batter at culvert outlets
Highly erodible batter at culvert outlets
Highly erodible batter at culvert outlets
Highly erodible batter at culvert outlets
Highly erodible batter at culvert outlets
Undermining of concrete shute
This concrete shute will collapse due to erosion and undermining.
TYPICAL ROAD EMBANKMENT AND DRAINAGE PROBLEMS

GULLY EROSION
Roadside gully erosion
If let unchecked, gully erosion can eventually undermine road pavement.
Unless repaired this gully will shortly undermine the road in the background.
TYPICAL ROAD EMBANKMENT AND DRAINAGE PROBLEMS

TUNNEL EROSION
Underground piping threatens the stability of road pavement.
If unchecked this pipe will eventually cause the road to collapse
RESULTS OF TRIALS

CUT AND FILL BATTER

PROTECTION
Fill batter stabilisation
Three months after planting
Three months after planting
Three months after planting
Seven months later
Highly erodible cut batter prior to vetiver planting.
Three months after planting
General view, three months after planting
General view, seven months after planting
Completely stabilised seven months after planting
Hydromulching three months after planting
Hydromulching seven months after planting
RESULTS OF TRIALS

GULLY EROSION CONTROL
Gully erosion stabilisation
Gully erosion stabilisation
RESULTS OF TRIALS

SUBSTITUTION OF CONCRETE SHOULDER DYKES WITH VETIVER HEDGES
Expensive concrete shoulder dyke built to protect culvert outlet
Vetiver hedges planted on edge of road shoulder provide same protection but cheaper and more effective.
Vetiver hedges planted on edge of road shoulder to protect culvert inlet
Vetiver hedges planted on edge of road shoulder to protect culvert inlet, note no erosion
Vetiver hedge traps loose road gravel, reinforcing the road shoulder
Collect and divert surface runoff to concrete shute
Concrete shute inlet
Vetiver outlet used to drain off water accumulated along shoulder dykes
Vetiver outlet along concrete shoulder dyke
RESULTS OF TRIALS

EROSION CONTROL IN WIDE TABLE DRAINS
On highly erodible soil, rock check dams along wide table drain do not work as water just cut through the side.
On wide table drain, short rows of vetiver planted on contour line, spread water flow, reduced flow velocity and trapped sediment.
Short rows of vetiver planted on wide table drain will spread water flow, reduce flow velocity and trap sediment.
Short rows of vetiver planted on wide table drain will reduce erosion
Short rows of vetiver planted on wide table drain will reduce erosion
General layout
A series of well laid out vetiver rows provide effective erosion and sediment control on wide table drain.
RESULTS OF TRIALS

PROTECTION OF RIP-RAP ROCK AND ROCK CHECK DAM
The deep root of the vetiver row stops water from undermining the rock cover of this shute
The deep root of the vetiver row stops water from undermining this rock check dam
The thick hedges spread water flow and the deep root stops water from undermining the rock cover
The thick hedges can be used to divert water flow into more protected surface
APPLICATIONS IN NEW ROAD CONSTRUCTION

PLANTING MATERIAL
*Left:* A good quality tube stock with at least 3 advanced shoots and well developed roots is recommended  

*Right:* This immature tube is not acceptable
Good quality planting material was delivered and kept fresh in stockpile area close to road work
APPLICATIONS IN NEW ROAD CONSTRUCTION

Stabilisation of steep batters above culvert inlets and outlets
Typical erosion on unprotected batters of culvert inlets and outlets
Typical erosion and sedimentation problem on unprotected batters of culvert inlets and outlets
Steep batter protected by vetiver hedges
Steep batter protected by vetiver hedges
Steep batter protected by vetiver hedges
Close up view of steep batter protected by vetiver hedges
Close up view of steep batter protected by vetiver hedges
Close up view of steep batter protected by vetiver hedges
Three weeks after planting
APPLICATIONS IN NEW ROAD CONSTRUCTION

Stabilisation of road batters
Batter protected by vetiver contour planting at between 0.5 and 1.0m Vertical Interval
Three weeks after planting
Three weeks after planting
APPLICATIONS IN NEW ROAD CONSTRUCTION

Protection of rock structures
Undermining of rock structures on erodible soil is prevented by the deep and extensive root system of vetiver grass.
Three weeks after planting
Undermining of rock structures on erodible soil is prevented by the deep and extensive root system of vetiver grass.
Three weeks after planting
Undermining of rock structures on erodible soil is prevented by the deep and extensive root system of vetiver grass.
Three weeks after planting
Surface erosion around rock structures at culvert inlets and outlets built on erodible soil is minimised by spreading concentrated flow.
Surface erosion around rock structures at culvert inlets and outlets built on erodible soil is minimised by spreading concentrated flow
Three weeks after planting
These hedges will spread and slow runoff water from this steep slope
These hedges will spread and slow runoff water from this steep slope
COSTS SUMMARY
AND
CONCLUSION
## Cost Summaries

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

- Vetiver hedge can be rapidly established in arid conditions and poor soils with little if any nutrients.
- Once established vetiver hedges are maintenance free and withstand arid and dry season conditions including bush fires.
- Provides protection to steep cuts and fill batters resulting in substantial savings in earthwork costs.
- Encourages sheet flow and reduced water run-off velocities resulting in natural vegetation re-growth and prevention of erosion.
- Eliminates undermining of hard rock structures
- Effective alternative to hard rock check dams
- Effective prevention of gully erosion
- Very cost effective, with savings ranging from 73% for culvert protection to 64% for table drain and is miscellaneous protection works and 60% for road shoulder protection.
- In highly erodible soils, the most important advantage of vetiver technology over conventional structures is that rock structures themselves are not stable and required constant maintenance to protect the road works which will add to the overall operating costs of infrastructure in the long term.