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

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***ABSTRACT***

*New road construction works along improved horizontal and vertical alignments require substantial clearing of the natural vegetation and the earthworks required very often involves major cut and fill embankments. Construction of associated bridges and culverts also result in a corresponding disturbance to the existing vegetation. Resulting from these construction activities extensive areas of disturbed land are placed at risk of erosion. These risks are exacerbated in areas of the wet tropics of Australia, which are subject to high intensity rainfall. The wet tropical regions of Australia also extend over vast areas with a diversity of soil types including highly dispersive soils containing little if any nutrients.*

*In the wet tropics of Far North Queensland vetiver contour hedges have recently been established as a rapid and effective method of stabilising new road embankments and other disturbed areas. Other trials undertaken with substitution of vetiver contour hedges to control storm water runoff, in lieu of the traditional and expensive methods of constructing rock check dams in table drains and culvert outlets, concrete shoulder dykes and treatment of areas subject to piping are encouraging in respect of their effectiveness and attractive cost benefits.*

## 1. INTRODUCTION

The wet tropics of Australia extend over a vast area of the Northern Australian continent and are subjected to well-defined wet and dry seasons. The wet season, which generally extends from December to April, is subject to high intensity rains whilst the dry season is dry and dusty with little if any rain at all. The region also contains a diversity of soil types with sound materials suitable for road construction purposes often difficult to find. For example the soil, on which the road described below was built, is very poor in plant nutrients (Table1), which makes stabilisation by plants very difficult. Therefore it is highly erodible under high rainfall conditions.

This lack of suitable materials often results in road batters and table drains being subject to deterioration by erosion and if left untreated, would result in failure of the embankments and place the road itself in jeopardy. In addition when erosion occurred, this would cause the unwanted transportation of sediment along natural water courses.

The realignment of creek beds for bridge and culvert construction works involves disturbance of natural vegetation leaving these areas at risk of erosion. Traditional protection of these disturbed areas with hard rock rip-rap, rock mattresses and gabions are expensive solutions. In some areas suitable naturally occurring hard rock is scarce or does not exist resulting in substantial cost penalties on account of the haul distances involved in transporting materials to the work site.

**Table 1: Chemical analyses of a typical wet tropic region of Australia.**

| Analyses | Units | Levels |
|---|---|---|
| **PH** | | 7.3 |
| **EC** | mS/cm | 0.01 |
| **Cl** | mg/kg | BQ |
| **N03-N** | mg/kg | BQ |
| **P** | mg/kg | 4.0 |
| **Ca** | meq/100g | 1.4 |
| **Mg** | meq/100g | 2.2 |
| **Na** | meq/100g | 0.04 |
| **K** | meq/100g | 0.11 |

BQ Below Quantification

The high intensity seasonal rains and the diversity of soil types in the wet tropical regions of Australia pose particular problems to road and bridge construction engineers. Whilst you may well say that engineers should program their construction activities to take account of the wet and dry seasons, financial and political pressures invariably dictate otherwise and some construction activities, with the exception of major earthworks, often extend through the wet season.

This paper describes some of the road construction problems encountered and the trials undertaken using various applications of Vetiver Grass Technology (VGT). Results of these trials have been encouraging and further work has been undertaken using vetiver hedges to protect recent road infrastructure projects in Far North Queensland with considerable success. Various applications of VGT will be discussed and this paper also provides a cost benefit summary by comparing costs of VGT with traditional protection using concrete and hard rock structures.

## 2. TYPICAL ROAD EMBANKMENT AND DRAINAGE PROBLEMS

### 2.1 Erosion of Cut Batters

Without protection the cut batters constructed in highly erodible soils would be easily eroded by high intensity rainfall during the wet season. In many cases these soils are also deficient in nutrients which make stabilisation by vegetative means very slow and difficult. The common method of stabilisation by hydromulch treatment to these cut batters has not provided sufficient cover or root structure to protect the batters from erosion.

### 2.2 Erosion of Fill Batters

#### *2.2.1 Steep (1:1) Batters*

If unprotected, fill batters are very prone to erosion by high intensity rainfall and runoff water from road surface. This will eventually lead to damage to the road shoulders. The conventional concrete shoulder dykes are very costly and provide insufficient protection to the shoulders of the road built on this highly erodible soil. Attempts to stabilise the fill batters with hard rock protection have not been successful due to the undermining of the rock structure.

*2.2.2 Steep Batters at Culverts*

The steep slope above culverts is easily eroded. This often results in the road shoulder, culvert wing walls and culvert apron being undermined. Attempts to protect fill batters, batter chutes and culverts with traditional methods such as hard rock rip rap are expensive and often failed due to undermining.

## 2.3 Gully Erosion Threatening Adjoining Road Works

Gully erosion on this road is very severe and if left unchecked gully erosion will recess upstream
and eventually undermine the adjoining road pavement.

## 2.4 Underground Piping

Any movement of water beneath the road pavement on this highly sodic soil will wash out fine soil particles leaving voids, which eventually collapse and cause the road to fail.

# 3. RESULTS OF PRELIMINARY TRIALS

## 3.1 Cut and Fill Batter Protection

Initial planting of vetiver hedges on cut and fill batters was carried out in December 1998. Very good establishment of vetiver hedges was achieved 5 weeks after planting.

Vetiver hedges were almost 1m high three months after planting and excellent growth reaching 1.5 meter high five months after planting. The batters were successfully stabilised by vetiver hedges in April 1999, 5 months after planting. This is in sharp contrast to the control areas and those protected with hydromulching, which were badly eroded by the high intensity storms during the wet season. In addition it was also noted that a single vetiver hedge planted on the edge of the road shoulder encouraged the establishment of natural vegetation down the steep fill batter.

## 3.2 Gully Erosion Control

In the gullies, establishment of vetiver contour hedges encouraged sheet flow with reduced velocities and the re-establishment of natural vegetation between the hedges.

## 3.3 Replacement and Substitution of Road Concrete Shoulder Dykes with Vetiver Hedges

The establishment of vetiver hedges on the edge of road shoulder has also successfully replaced the traditional concrete road should dykes. This allows controlled low velocity flows down the batter to support natural batter revegetation but also directs large flows to concrete batter chutes. In addition the dense hedges also trapped gravel moving from the new road surface thus strengthening the road shoulders.

### 3.4 Application of Vetiver Contour Hedges in Wide Table Drains

When planting in short rows on contour lines along the table drains, vetiver hedges encourage low velocity sheet flow, trap sediment and promote re-establishment of natural vegetation between the hedges, which further reduce the risk of erosion. The conventional practice of constructing rock check dams in these table drains provided no protection against erosion in this highly erodible soil.

### 3.5 Vetiver Grass used in Combination with Rip-Rap Rock Protection and a Rock Check Dam

When planting around rock structures, vetiver hedges with their deep root systems prevent these structures from being undermined. Vetiver was very effective in protecting rip-rap rock structures and a rock check dam in a narrow table drain.

## 4. RECENT ROAD CONSTRUCTION WORK

The success of the preliminary trial has led to further applications of VGT in erosion and sediment control on a new road in the same region.

On this new road vetiver hedges were used for the stabilisation of fill batters including steep fill batters at culverts and to protect culvert inlets. When planted at culvert inlets vetiver hedges encourage sheet flow and reduced stream velocities to prevent erosion. When gabions were used to protect the upstream bank of culvert inlets, vetiver contour hedges were planted in the gabion backfill to prevent it from undercutting.

Vetiver hedges were also used to protect culvert outlets, which are often severely damaged by high velocity flows. Vetiver contour hedges were also planted in the backfill to prevent undermining of the downstream gabions.

## 5. COST COMPARISONS

### 5.1 Unit Rates

The unit rates given in this paper are expressed in Australian dollars (AUD). Also the unit rates are for road construction projects in remote areas of Northern Queensland some 300 to 400 km from the nearest main centre and therefore include significant transport costs.

| **Vetiver Grass Treatment**<br>*Note that all rates are given per linear meter on the basis of 7 plants per linear meter.* | **Units** | **AUD** |
|---|---|---|
| Supply of vetiver planting material in tubes from main centre nurseries | m | 8.50 |
| Transport to site, plant, water and fertilise | m | 7.00 |
| **Total for supply and planting vetiver hedges** | **m** | **15.50** |

| | Units | AUD |
|---|---|---|
| **Haymulch Treatment** | | |
| Supply mulch, spray and water | $m^2$ | **1.60** |
| **Hard Rock Treatment** | | |
| Dump Rock | $m^3$ | **21.00** |
| Selected Rip Rap | $m^3$ | **65.00** |
| Grouted Rock Pitching | $m^2$ | **66.00** |
| Steel Wire Rock Mattress | $m^2$ | **43.00** |
| Rock Check Dams | m | **42.00** |
| **Concrete Structures** | | |
| Road Shoulder Dykes | m | **38.00** |
| Batter Chutes | $m^2$ | **70.00** |

## 5.2 Cut Batters

### *5.2.1 Vetiver Contour Hedges*

Earth cut batters are generally constructed at a slope of 1:1. Cut batters are generally hard and require preparation in the form of 300mm wide contour benches to facilitate the planting of vetiver, retention of water and fertiliser. These benches are machined cut at an extra cost of AUD 3.00 per meter making the total cost of vetiver hedges on cut batters AUD 18.40 per linear meter, which is equivalent to AUD 21.40 per square meter

### *5.2.2 Haymulch Treatment to Cut Batters*

The alternative use of hay mulch at AUD 1.60 per square meter on 1:1 or steeper batters rarely provides suitable cover for protecting these batters against erosion. For hay mulch to provide effective protection against erosion it is necessary to flatten the batters to 1:2 or even flatter depending on the nature of the soil. Flatter batters attract substantially increased earthwork costs, which negate any cost savings achieved.

## 5.3 Fill Batters

### *5.3.1 Vetiver Contour Hedges*

Earth fill batters are generally constructed at 1:1 slopes and steeper over culverts. Machine benching of fill batters is not required and the cost of protecting fill batters does not exceed AUD 15.50 per linear meter**,** which is equivalent to AUD 18.20 per square meter

### *5.3.2 Hay mulch Treatment to Fill Batters*

The alternative use of hay mulch treatment on fill batters does not provide adequate treatment unless the batters are constructed to 1 on 4 or flatter slopes

### 5.4 Cost Summaries

| **Road Batter Protection** | AUD Per linear metre | AUD Per square meter of batter face |
|---|---|---|
| Vetiver hedges on Cut Batters | 18.40 | 21.40 |
| Vetiver hedges on Fill Batters | 15.50 | 18.20 |
| **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%** |

## 6. CONCLUSIONS

- The advantages of using vetiver hedges for protection of road infrastructure works are summarised as follows:

- 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 runoff 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 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.

**INTRODUCE DR PAUL TRUONG**

Help:  The rains are coming and this new road is going to collapse in a heap