

SPECIAL PROJECT REPORT

SPR X/2004

**PERFORMANCE  
ASSESSMENT OF GREENING  
TECHNIQUES ON SLOPES**

**B.L.S. Lui & Y.K. Shiu**

**June 2004  
Special Projects Division**

## **1. INTRODUCTION**

As part of the recent initiatives to enhance the aesthetics of man-made slopes, the Geotechnical Engineering Office (GEO) of the Civil Engineering Department and other slope maintenance departments have been applying different greening techniques on slopes. A study has been undertaken to review the performance of these techniques.

This study includes assessment of the growth condition of vegetation on slopes where the greening techniques have been applied, and evaluation of the engineering performance of the techniques. Dr Billy C H Hau of the University of Hong Kong has been engaged by GEO to assess the growth condition of vegetation.

To oversee the study, a working group with representatives from the GEO and nine other government departments was established in September 2002. The membership of the working group is given in Appendix A.

This report describes the details and findings of the study, together with recommendations for improvements. It should not be construed as endorsement or rejection of any techniques or products.

## **4. GREENING TECHNIQUES STUDIED**

### **4.1 General**

Twenty-four proprietary products for slopes greening were reviewed in this study and they are listed in Table 2. The products are broadly classified into the following two groups of techniques:

- (a) Group 1 Techniques: Products that are applied on slopes with a hard surface cover,
- (b) Group 2 Techniques: Products that are used directly on exposed soil slope surface.

### **4.2 Group 1 Techniques**

#### **4.2.1 General**

A total of 16 proprietary products have been used under the Group 1 techniques. They are broadly classified into the following four techniques according to their general characteristics:

- (a) mulching system
- (b) cellular system
- (c) reinforced soil
- (d) bioengineering method

#### 4.2.2 Mulching System

The following eight proprietary products are classified under the technique of mulching system:

- Biocrete
- Hong Kong Mulching
- NFY Hydro-Mulching
- “On” Method
- Rocksgrass
- CMS-ML Green System
- Soil Panel
- Toyo-Mulching

#### 7.2.3 Results of the Present Study

From the results of vegetation assessment made during the three inspections (Table E1 in Appendix E), most of the slopes applied with # or Rocksgrass had consistently high percentage of healthy vegetation cover, above 80% for over half of the slopes studied. For#, the two slopes studied were also noted to have healthy vegetation cover of more than or around 70% in the first and second inspections. Owing to the small sample size of the product, it is difficult to determine its performance with certainty.

The engineering performance of#, Rocksgrass and # was found to be better than the other mulching products.

#### **E.2.6 Rocksgrass**

The mulch/soil mix in this system is alternately interbedded with three layers of non-biodegradable mat and two layers of biodegradable mat. Typical details of the system are shown in Figure 5.

##### **E.2.6.1 Vegetation Assessment**

Growth conditions of vegetation on eight slopes were surveyed. All the slopes were planted with grasses and creepers and/ or climbers. All slopes were inspected twice except that slope 11SW-D/C111 was inspected three times. The overall percentage cover of slopes treated with this product is very good. Six out of eight slopes were recorded to have more than 80% total exposed and healthy vegetation cover (Table E1). In addition, four of these six slopes have the planted grass and *Wedelia trilobata* as the main ground vegetation cover. For the other two slopes, slope 11SE-C/C753 was dominated by the remnant trees as the main vegetation cover on the slope. The main vegetation cover of the remaining slope (11SW-C/C385) was

formed both by planted species and existing trees on slopes. In the second inspection, except two slopes that reached 100% of total of total exposed vegetation cover, the total exposed vegetation cover of the remaining slopes was only found decreased slightly in the second inspection. However, both the percentage total exposed and healthy vegetation cover of slope C111 had recovered to a satisfactory level of more than 83% at the third inspection after the drop in the second inspection. This suggests that this technique may be able to retain soil moisture better during the winter dry season.

The species diversity and richness of naturally occurring woody plant species vary greatly amongst the slopes. However, the difference in most slopes between the two inspections is not large (Table E1). This product may be able to support small shrubs owing to its apparent ability to maintain soil moisture in the winter dry season and a thicker plant growth medium.

#### **E.2.6.2 Engineering Assessment**

Two slopes no 11NW-D/C130 and 11SW-D/C111 were inspected for engineering assessment of this product. On slope C130, mild steel bars of 10 mm diameter are fixed on to the surface of the soil mix horizontally across the slope at a vertical spacing of about 1.5 m (Plate 7a). These horizontal bars act as bracing to provide additional support to the soil mix. Minor bulges of the mulch/soil mix were noted and they were confined by the horizontal steel bars. There were no apparent signs of surface cracking or detachment of soil mix. A layer of long-term non-degradable erosion control mat was provided on the surface of the two slopes. No sign of weakening was noted on these mats at the time of inspection and they were securely anchored on the slopes with tension. Edges of the system were noted to be well-protected by mats pinned on the slope.

Table 2 - List of Proprietary Products Reviewed

Groups	Types of Greening Techniques	Names of Proprietary Products	Estimated Installation Cost <sup>(Note)</sup> (per m <sup>2</sup> )
Group 1 - Techniques applied on slopes with hard cover	Mulching	#	\$650-\$750
		#	\$800-\$900
		#	\$600-\$1,000
		#	\$800-\$1,250
		<b>Rocksgrass</b>	<b>\$600-\$750</b>
		#	\$600-\$750
		#	\$1,000-\$1,150
	Cellular System	#	\$800-\$1,700
		#	\$660-\$1,250
		#	\$450-\$750
		#	\$600
		#	\$600-\$700
		#	\$600-\$1,000
		#	\$200

Table 3 - Summary of Results of Vegetation Growth Assessment for Slopes under Category of Mulching System (Sheet 2 of 2)

Greening Products	Construction Details in Figure No.	Slopes inspected	Observations during inspection	Relevant Section of Appendix E
<b>Rocksgrass</b>	5	3SW-B/C292 11NE-C/C62 11NW-D/C130 11NW-D/C52 11SE-C/C753 11SW-A/C142 11SW-C/C385 11SW-D/C111	<ul style="list-style-type: none"> <li>All slopes were planted with grasses and creepers and/ or climbers.</li> <li>Overall vegetation cover of the slopes ranged from 66% to 100%. No significant difference in vegetation cover between the 1<sup>st</sup> and 2<sup>nd</sup> inspections.</li> <li>In the 2<sup>nd</sup> inspection, two slopes reached 100% of total exposed vegetation cover and the remainder ranged from 66% to 93%.</li> <li>Overall percentage cover of vegetation on slopes treated with this product was very good.</li> <li>On slope C62, both H and S were recorded as zero whereas on slope C753, H were recorded to be marginally high (between 1.89 to 2) and S were high (between 12 and 13).</li> <li>H recorded on the other slopes were low (between 0.42 to 1.9) whereas S were low to high (between 4 and 11).</li> <li>This product may be able to support small shrubs owing to their ability to maintain soil moisture.</li> </ul>	E.2.6.1

Table 17 - Summary of Merits and Limitations of Different Proprietary Products of Group 1 Techniques (Sheet 1 of 3)

Techniques	Products	Merits	Limitations
Mulching	<b>Rocksgrass</b>	<ul style="list-style-type: none"> <li><b>High vegetation cover</b></li> <li><b>Quick installation</b></li> <li><b>Able to support small shrubs owing to the ability to maintain soil moisture</b></li> <li><b>Able to form smooth finished surface on uneven slope profile</b></li> <li><b>Good engineering performance</b></li> </ul>	<ul style="list-style-type: none"> <li><b>Nil</b></li> </ul>





Plate 7a

Observations: Horizontal bracing in the form of steel bars on system surface  
Slope No.: 11NW-D/C130  
Location: Chung Hau Street, Homantin  
Date of Inspection: 7 May 2003

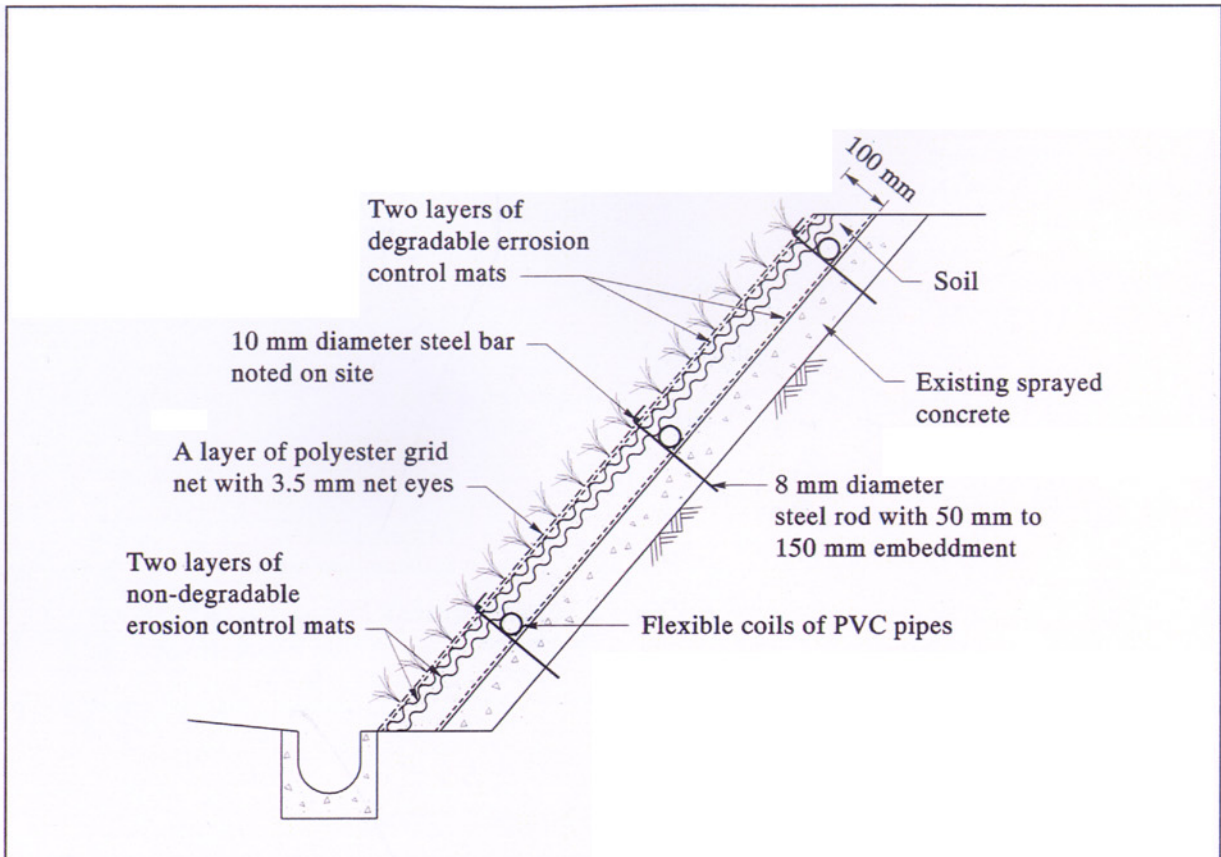


Plate 7b

Observations: Horizontal support within the soil mix in the form of PVC pipes  
Slope No.: 11NW-D/C131  
Location: Chung Hau Street, Homantin  
Date of Inspection: 14 October 2003

Plate 7 - Horizontal Support of Rockgrass





Typical details based on supplier's information  
(not to scale)



Overall view of slope treated with  
Rocksgrass



Close-up view

Construction method (based on information provided by the product supplier):

- An 100 mm-thick composite layer, interbedded with soil and 5 layers of mats, is applied onto slope surface by hand. Horizontal rows of flexible coils of PVC pipes are also provided in the composite layer.
- The composite layer is anchored on the slope with steel rods.
- Mild steel bars, which have not been mentioned in supplier's brochure, were noted to be fixed onto the surface of the composite layer horizontally at vertical spacing of about 1.5 m. The finished slope surface is hydroseeded and planted with creepers.

Figure 5 - Details of Rocksgrass