APPENDIX A

BRIEF

Agreement No. GEO 9/98
Review of Effective Methods of Integrating Man-made Slopes and Retaining Walls (Particularly for Roadside Slopes) into Their Surroundings

Brief

1. BACKGROUND

The poor visual appearance of some of the man-made slopes and retaining walls (hereafter referred to collectively as 'slopes' in Hong Kong) has been the subject of much debate in the media. Press headings such as *"Curb Landslide Problem With Eco-engineering"*, *"Too Much Concrete"* and *"Territory Slopes Policy Needed"* (ref : extracts from South China Morning Post in GEO News, Issue No. 182, March 1997) reveal public concern regarding the poor visual appearance of some of the slopes, especially those alongside the roads. Complaints from the public regarding the adverse visual impact of slopes are not a new phenomenon. There has been an increasing demand from the public for improving the appearance of the slopes so that they could integrate better into their surroundings.

Works Branch Technical Circular (WBTC) No. 25/93 "Control of Visual Impact of Slopes" recognises that the practice of the design of slopes needs to be improved and provides advice on "the design principles recommended to be used in designing man-made slopes ..... to reduce their adverse visual impact".

Guidance on the provision of surface covers, such as grass, trees and shrubs, chunam, sprayed concrete and masonry facing, to slopes is given in the Geotechnical Manual for Slopes. Also, some guiding principles for softening the visual impacts of the slopes are given in the Manual (for example, vegetative cover as opposed to rigid surface protection should be used whenever possible, colourants can be added to chunam or sprayed concrete for reducing the excessive reflection of sunlight, trees should be planted in rings formed on surfaces if rigid surface protection has to be used, etc.). However, the guidance concentrates more on treating these measures primarily as surface protection to reduce rainfall infiltration or surface erosion and less discussion is given on measures to soften the visual impact of slopes. Since the publish of the Manual, more experience has been learned from case histories of success and failure in landscaping design for slopes and new techniques may have been developed. It is therefore considered timely to review the experience learned and to give more up-to-date guidance on methods which could be more effectively integrating the slopes into their surroundings, particularly for roadside slopes.

2. OBJECTIVE

The objective of the study is to carry out the reviews as required in Section 3 and to recommend a set of guidelines and principles on ways to soften the visual impact of slopes and to effectively integrate slopes into their surroundings in Hong Kong, particularly for roadside slopes.

3. SCOPE OF THE STUDY

The scope of the study is as follows:

a) carry out a comprehensive review of local and international practices on methods for reducing the visual impacts of roadside slopes and blending of long linear road features with the environment, such as the use of geotextiles, the application of bio-engineering, eco-engineering, landscaping treatments, etc., and to recommend methods that are suitable for use in Hong Kong,

b) carry out a comprehensive review of the case histories, including interviews with project engineers, consultants and contractors for Landslip Preventive Measures (LPM) works and highway projects, and to document with good quality photographs and figures, of the successes and failures in landscaping design. The review shall include performance of different surface covers, visual impact of different slope geometry and design, and landscaping treatment methods for slopes, particularly for roadside slopes. The review shall also include, but not necessarily be limited to the following:

Soft solutions	• Hydroseeding • hydroseeding with tree seeds • hydroseeding with woodland/shrub planting • hydrosprigging "Soil Guard"
Mixed construction	• "ON" method • landscape treatments for soil nailed slopes • landscape treatments for rock and rock fill slopes • reinforced soil/stabilization with geotextile • cement stabilized fill options • cellular confinement systems • modular system
Inert construction	• wall facings and finishes • caisson/bore pile retaining walls • reinforced fill walls • crib walls • berm planters • toe wall planters • sprayed concrete (with/without pigment) • stone pitching
Retaining existing trees	• tree rings • planters around retained trees
Slope geometry	• size, shape and angle of slope • disposition of berms • detailing of associated features such as stairway, drainage channels, catchpits, etc.

(The review shall include an evaluation of the effectiveness of each option as slope treatment works, its limitations and the conditions that will ensure its success from both geotechnical and aesthetic viewpoints as well as its ease of construction and establishment on slopes in different seasons, durability in the urban environment, order of costs and likely frequency, cost and ease of maintenance.)

c) carry out a review on the products and techniques used locally and overseas for softening the visual impact of slopes with a view to recommend suitable ones that could be suitably adopted for use in Hong Kong, with cost and performance data as well as maintenance requirements provided where available, and

d) develop a set of concise guidelines and principles based on the above reviews on ways to effectively integrate slopes into their surroundings in Hong Kong, particularly for roadside slopes. There should be guidelines for both new slopes and for improvement of existing slopes, and also, if possible, guidelines on when existing impermeable slope covers could be removed and replaced with vegetation covers without increasing the risk of slope failures. The guidelines and principles shall be agreeable to Highways Department and other relevant Government departments responsible for slope maintenance. Model specification clauses should be prepared for use with HKSAR Government forms of contracts. Good quality photographs and figures to illustrate the principles shall also be included.

4. DELIVERABLES

The Consultants shall submit to the Director's Representative an Inception Report detailing the method statement and programme of the Assignment within two weeks and ten copies of a draft Final Report for comments within six months after commencement of the Assignment. Ten copies of a Final Report taking into account all the comments shall be submitted within eight months after the commencement of the Assignment A soft copy of the Final Report shall also be submitted at the same time. The Final Reports shall include, inter alia, the following:

(a) an executive summary, which shall be limited to 2 pages,

(b) the results of the reviews, recommendations and guidance as required under items (a) to (c) in Section 3, which shall be limited to about 30 pages (excluding tables, figures, plates and appendices)

(c) the concise guidelines and principles as required under item (d) in Section 3 as an Appendix which shall be limited to 2 pages (excluding tables, figures and photographs), and

(d) a list of reference for the documents reviewed in standard GEO format. Copies of the references shall be provided separately.

Comments on the draft Final Report will be provided to the Consultants within about

one month of receipt. The Consultants shall take the comments into account in producing the Final Report and provide a table of responses within two weeks of receipt.

The Consultants shall submit progress reports at monthly intervals. Where required by the Director's Representative, the Consultants shall attend progress meetings and give a presentation on the findings of the Assignment at the end of the studies, prior to finalising the Report.

The Final Report shall be produced in GEO Report format.

5. PAYMENT SCHEDULE

20% lump sum fee will be paid after submission of the Inception Report, and 50% of the lump sum fee will be paid after the submission of the draft Final Report. 30% of the lump sum fee will be paid after the submission of the Final Report.

APPENDIX B

CASE STUDIES

CASE STUDIES

Seventeen slopeworks were selected as Case Studies. The purpose of the Case Studies was to examine the role of the landscape architect at each stage of the design process and the effectiveness of the landscape treatment both in an engineering sense and visually. The selection of slopes for Case Studies was from the 200 slopes of the overall review (Volume 2) and with the addition of several slopes jointly suggested by the Steering Committee. It was important in the Case Studies selection that the slopeworks were relatively recent to facilitate the tracing of records and individuals involved. To speed up the interview process, interviews were limited to the parties involved in this project and in LPM works.

The Case Studies were constrained by time and the information which was obtainable in the available time. Some involved personnel had moved to other works or to other contracts and, in some cases, relevant information had not been archived.

List of Case Studies

1. Caine Road, Mid-Levels
2. Ching Hong Road, Tsing Yi
3. Shum Wan Road, Aberdeen
4. Yam O Wan, North Lantau Expressway
5. Ap Lei Chau Bridge Road, Ap Lei Chau
6. Sai Sha Road (1)
7. Sai Sha Road (2)
8. Wong Nai Chung Gap Road
9. Lion Rock Tunnel Road
10. Sheung Fung Street
11. Above Lion Rock High Level No. 2 Service Reservoir
12. Lam Tei Quarry
13. Turret Hill Ex-Quarry at Shatin
14. Hong Kong City Polytechnic (University)
15. Below Cape Collinson Crematorium
16. No. 9A Bonham Road
17. Gascoigne Road

1. Caine Road, Mid-Levels

This feature, 11SW-A/R116, between Caine Road and Castle Road, is a 40 m long masonry wall with a narrow 0.8 m wide footpath at the toe. The wall was selected by the GEO for inclusion in the 1995/96 LPM Programme under the category of "High Consequence to Life" as a result of an inspection in 1995.

Halcrow Asia Partnership Ltd. (HAPL) was appointed by GEO under Agreement No. CE9/95 to carry out stability studies, design and construction of LPM of the slope. Stability analysis showed that the southeastern portion of the wall, which contained 3 existing *Ficus microcarpa*, was unsatisfactory and remedial works to improve the wall to the required standard were necessary. A reinforced concrete skin wall was selected amongst 4 options as the most suitable solution. Landscape design was considered following the Option Assessment and was undertaken by Urbis Limited who were engaged as sub-consultants. Urbis were tasked with softening the visual impact of the new wall using vegetation. Due to the constraints of limited planting space at the toe, plants with shallow roots and roadside tolerant plants were initially proposed. However, USD requested three deep-root trees, *Ficus microcarpa*, at whip size to be planted to compensate for the loss of the three existing *Ficus microcarpa.* Discussions between the designer and landscaper resulted in the toe design of the wall being revised to allow the construction of a deeper toe planter to accommodate the trees.

This case successfully demonstrated the integration between the engineer and landscape architect to enhance the visual quality of the wall. The finished product is to the satisfaction of the engineer and the landscape architect.

2. Ching Hong Road, Tsing Yi

This feature, 10NE-B/C10, is located at Ching Hong Road, Tsing Yi. The rock cut slope is 15 m to 18 m high and 90 m long with a slope angle of 80°. The slope was included in LPM in 1996 due to "High Consequence to Life". Mouchel Asia Limited designed the slope with landscape sub-consultant Earthasia Limited.

The objective of the work was to upgrade the slope to current standards. A major constraint was the public housing estate at the crest. The slope was affected by random jointing and potential toppling failures. Grading of the slope was not possible because of the public housing estate at the crest and an option of rock dowels and sprayed concrete was chosen from among several options. The designer regarded plain sprayed concrete as not visually pleasing, and painting of the sprayed concrete was selected as a landscape treatment. After discussion between the engineer and landscape architect from Earthasia and Highways Department, it was decided that the painting would consist of 2 coats of water based paint, colour "Antique" (code 10B25), covered by spotty dark green colour specified by Highways Department (colour 5040-G) over 25% of the surface area. During the construction, the upgrading work was supervised by RSS with landscaping work advised by landscape architect as required.

The finished product is considered a success in terms of visual appearance, with good communication between engineer and landscape architect. Latterly, leaching on the surface from weepholes (see overleaf) has unfortunately resulted in discolouration of the paint. In this particular case the designer initiated the process of adding colour to the sprayed concrete surface as it was not included in the LPM contract.

Discolouration of paint by leaching from weepholes

3. Shum Wan Road, Aberdeen

The slopes (slope Nos. 15NW-B/C6 and C334) at Shum Wan Road, Aberdeen were the site of a major fatal landslide in 1995 and they have recently been restored. The study site is about 70 m high, 75 m wide and 150 m in plan from toe to crest. Halcrow Asia Partnership Limited (HAPL) were appointed by Geotechnical Engineering Office (GEO) in 1996 to carry out permanent remedial works to the landslide scar and the adjacent hillside. Urbis Limited were landscape sub-consultants to HAPL.

Due to the geotechnically complex nature of the site, landscape issues were considered secondary. The upper slope with angles between 35° and 70° was covered by coloured sprayed concrete. The lower slope, mostly in soil was vegetated with grass and whips. Landscape architects at Highways Department were involved in giving comment and advice on landscape design of the slope.

The slope was geotechnically complex with rockhead at or close to the surface in places. The lack of soil and the rock exposure in the landslide scar were major constraints to re-vegetation. This was taken into consideration in the planting scheme. During planting works, different plant species were inadvertently used in the wrong locations. With no full-time suitably qualified landscape staff on site, this went unnoticed by the RSS, only being identified sometime later by the landscape architect. HAPL consider the landscape result as reasonably successful. The landscape sub-consultants consider some of the landscape objectives were not achieved due to limited time, lack of supervision, and absence of a landscape specialist on site.

4. Yam O Wan, North Lantau Expressway

The case study slope is located to the west of Yam O Wan on the North Lantau Expressway corridor. The Lantau Airport Express railway is at the toe of the slope. The slope is a rock and soil slope about 60 m high and 500 m long covered with sprayed concrete. The engineering design was undertaken by Mott MacDonald HK Ltd. in 1990 to 1992.

The original design was to leave, where possible, exposed rock surfaces, to provide planters on berms within the rock slope and vegetate the soil slope above. The cut slope was originally designed with rock bolts and dowels and sprayed concrete where necessary. The design was however altered in response to comments from the Railway Inspectorate who considered that rockfall may represent a risk to the railway line at the toe. The slope design was latterly altered to include a total cover of sprayed concrete. The slope was cut to 65° with 3 m wide berms at 15 m vertical intervals. In order to improve the visual appearance, Highways Department, in 1996, appointed Clouston landscape consultant and Asian Rock as nominated sub-contractor to design a painting pattern and to paint the sprayed concrete slope. A resident landscape architect supervised the landscaping work on site and the paint design was modified on site to suit the slope conditions during the painting work.

The slope is considered a success in terms of engineering but considered a failure in terms of visual appearance. The paint work has not effectively hidden the engineering works, which are still visible. The vegetation above the rock slope also failed to establish due to unsuitable ground conditions.

5. Ap Lei Chau Bridge Road, Ap Lei Chau

The case study area is situated adjacent and to the south of Ap Lei Chau Bridge Road and is surrounded by high rise residential buildings. To cater for the additional traffic generated by the new development in Ap Lei Chau, the existing single carriageway road between Ap Lei Chau Bridge and the South Horizon Development was upgraded to a 1.8 km dual carriageway in 1991.

HAPL were appointed by Secan Limited to carry out design work. Major retaining walls were designed including four sections of caisson walls approximately 7 m high and 300 m long, and five sections of traditional L-shape retaining wall extending over 400 m and averaging 5 m high. Two types of landscaping treatments were used: a chromatic tiled wall finish by Atelier CLER and re-vegetation of the slopes above the walls by Urbis Limited.

Atelier CLER carried out a chromatic study to establish the most suitable colours to use on tiles that were set into the walls. Four colours were selected as being appropriate for the character of the district: red (0090/Y80R), dark brown (5051/Y50R), light brown (3020/Y60R) and green (4020/G10Y). The tiles were arranged in vertical bands on the wall as specified by the chromatic design. The spacing, width and colour of the bands were based on 4 standard types of panel.

Urbis Limited designed the landscaping works above the walls with the objective of softening the visual impact of the new wall and re-vegetation of the slopes above the retaining walls.

Several landslides occurred in the densely vegetated slopes above the wall during and after the road widening work. Remedial work were carried out consequently which involved soil nail design. The works were implemented to minimise disturbance to the vegetation.

The overall scheme is considered successful. The agreement to include major retaining walls in the design allowed the upper part of the slope to be vegetated. The visual impact of the overall slope was further softened by the innovative use of coloured tiles.

6. Sai Sha Road (1)

The study slope, 8NW-C/C42 (formerly 8NW-C/C10) is located in Sai Sha Road. The slope angle is between 45° at the toe and 50° at the crest, with a slope height of 15 m. The slope was originally covered with chunam. The feature was recently upgraded as part of the LPM. The surface finish is hydroseeded grass with some localised masonry surfacing.

The upgrading designed was carried out by GEO to bring the slope up to current standards. From the option assessment study, a soil nail solution was adopted maintaining the original geometry. The option of cutting back was not considered feasible, partly on visual impact grounds, because of the steep, heavily wooded natural terrain above the slope. The slope works included removal of existing chunam, soil nailing and hydroseeding with erosion control mat. No landscape architect was involved in the design. During construction, seepage was noticed in a localised area at the toe of the slope. The hydroseeded surface at this location was subsequently replaced by hard surface, masonry facing. The decision to change the surface treatment was made by the design engineer with the considerations of time constraint and cost efficiency. There was no landscape specialist supervision during the construction of the slope.

Considering the constraints, the design engineer considers the finished slope aesthetically successful. This case demonstrates the problem with unforeseeable ground conditions during construction which may result in a change in slope landscape treatment.

7. Sai Sha Road (2)

The study feature, 8NW-C/C43 (formerly 8SW-C/C16), located in Sai Sha Road is 10 m high with a slope angle of 60°. It was placed in the LPM programme in 1996 because it is adjacent to a busy road. GEO were responsible for the slope design.

Design options included (1) cutting back or (2) soil nailing with toe planters and creeper pots, the latter being chosen mainly based on cost efficiency. It was considered that cutting back was not practical because of the low strength materials and the possibility of road closure. Owing to the steep slope angle (60°), hydroseeding was not considered and sprayed concrete was applied instead. Due to the closeness of Ma On Shan Country Park, AFD were involved and proposed that brown sprayed concrete should be used because the colour closely matched the natural rock colour. There was no landscape architect involved in the work.

The design engineer was not satisfied with the brown colour of the sprayed concrete because the colour did not blend in with the surrounding environment which is mainly vegetation.

8. Wong Nai Chung Gap Road

The study feature, slope No. 11SE-C/C40, is located in Wong Nai Chung Gap Road with natural terrain uphill. It is a 60° soil cut slope that was originally covered with chunam. The slope was constructed in 1978 and recently upgraded by GEO to current safety standards.

The major constraint in the upgrading works was the steep terrain uphill of the slope. Between the options of cutting back and soil nails, the preferred option was soil nails with brown sprayed concrete, planter holes and toe planter. Cutting back was not considered because of the steep terrain above. Landscaping issues were considered at the start of the design stage including brown sprayed concrete, planter holes and toe planter. The colour of the sprayed concrete was chosen by the designer. Construction work was completed in January 1999. The planting of vegetation in planter holes and toe planters was advised by Highways Department and was scheduled for September 1999.

The finished slope itself is considered visually successful. However, along Wong Nai Chung Gap Road, there are several sprayed concreted slopes within a short distance of one another with different colours.

9. Lion Rock Tunnel Road

The study site, slope No. 11NW-B/C635 (formerly 11NW-B/F106 & F115), is located immediately to the west of the southern portal of the Lion Rock Tunnel. The slope angle varies between 60° and 20°. The slope was upgraded as part of the LPM Programme and was designed by GEO with HyD as client. No landscape architect was involved. The upgrading work was completed in March 1998.

The objective of the design was to avoid liquefaction of the underlying fill material. Major constraints at the site were the busy traffic and water mains underneath the slope. GEO suggested sprayed concrete as the preferred engineering option. The option of re-compaction was not possible due to the disturbance to the busy traffic and the water mains underneath the slope. Two alternative options were suggested by the client, HyD: (1) erosion mat with hydroseeding, and (2) stone facing and toe wall planter. Hydroseed was not suitable in this situation because of the potential for liquefaction and the steepness of part of the slope (60°). The toe wall planter was also not feasible because of the utilities underneath the footpath. Following discussion between HyD and GEO a combined solution was adopted. The original profile would remain unchanged. On the 60° slope, soil nails with 100 mm sprayed concrete cover and stone facing were applied. Elsewhere, the fill slope was covered with stone facing with trees retained with tree rings. Stone facing arrangement, pattern and colour were designed by the engineer.

The result is considered good by the designer from both aesthetic and maintenance points of view and has generally been favourably received.

10. Sheung Fung Street

The study site is the south facing part of slope No. 11NE-A/C33, located at Sheung Fung Street. The slope originally comprised an upper 50° fill slope covered with chunam and vegetation, and a lower 60° cut slope also covered with chunam. The slope was in the LPM Programme in 1994 due to "high consequence to life". GEO designed the slope with clients Water Services Department (upper slope) and Housing Department (lower slope).

The main objective of the work was to upgrade the slope to current standard with a "green look" as required by the clients. A major constraint was a service reservoir located above the slope. Two options were suggested (1) recompaction and cutting back, and (2) soil nailing. Soil nailing was chosen because cutting back would have interfered with the service reservoir above. The design involved removal of the existing chunam, soil nailing, erosion control mat, and, at the toe, cement rendering of stone pitching. Hydroseed grass and tree seed mix were applied. There was no landscape architect involved in the design process.

The finished slope is considered to be visually acceptable but poor from an engineering point of view. Cracking and distress of drainage channels, and localised erosion on the slope have occurred. The slope has been greened, but the trees are generally small, leaning forward and with a poor root system. It would appear that the steepness may have contributed to the poor condition of the trees.

11. Above Lion Rock High Level No. 2 Service Reservoir

The study site, slope No. 11NW-B/C133, is located above Lion Rock High Level No. 2 Service Reservoir. The slope is a 60° soil cut slope that was included in the LPM programme by WSD because of erosion of the slope crest possibly affecting the reservoir at the toe. The slope was designed by GEO with WSD as client and the upgrading work was finished in 1997.

Among different design options considered were (1) retaining the original profile, soil nailing and the use of sprayed concrete, and (2) trimming the slope to 40° and hydroseeding. A combined solution was adopted based on cost effectiveness and appearance of the slope. The upper slope was cut to 45°, hydroseeded with a shrub and grass seed mix and a bio-degradable and synthetic erosion control mat placed on the slope surface. Chevron drainage was designed to increase flow velocity preventing blockage of channels. The lower slope was nailed with no cutting back and covered in sprayed concrete. No landscape architect was involved.

The design engineer is satisfied with the appearance of the finished slope. The green upper slope is highly visible and the vegetation used helps it blend into the surrounding hillside. The lower slope is generally hidden from view and the sprayed concrete cover cannot be seen. The appearance of the lightly coloured chevron drains stands out against the green slope and it was noted that colouring of the drains would further reduce the visual impact of the slope.

12. Lam Tei Quarry

Lam Tei Quarry is located to the north of Tuen Mun New Town and covers about 30.5 ha of land. The quarry started operation in 1982 and is scheduled to be completed in 1999. The quarry operator is required to provide landscaping and planting of the final approved landform. The final landform is 90% completed and programmed to be finished in 2001. Team 73 Hong Kong and Asia Stone Company are landscape sub-consultant and contractor respectively.

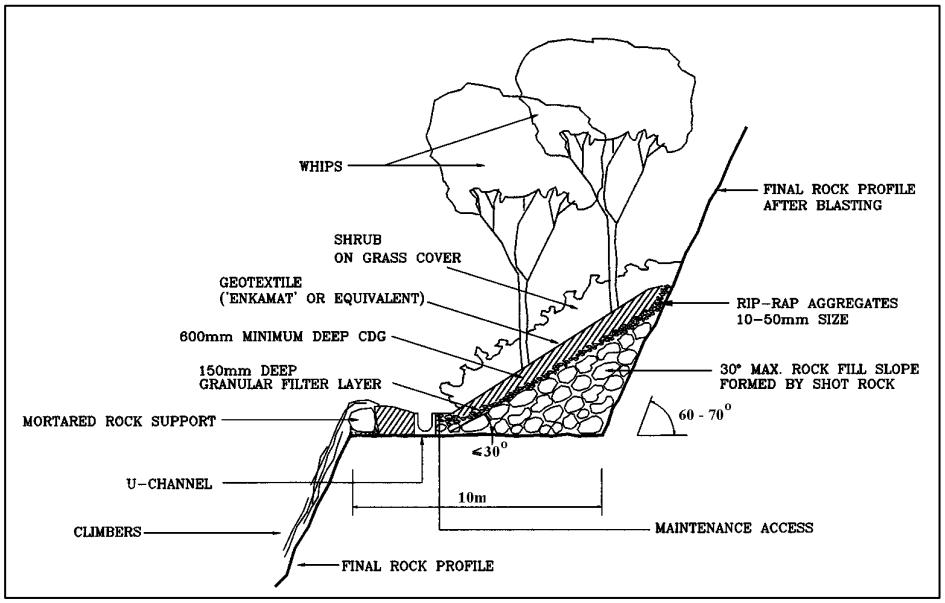
The objectives of the quarry landscape work are to re-vegetate the quarry face to a stable condition and blend it with its surroundings. To achieve this, planting has been undertaken on the berms using a climber, mixed tree/shrub and groundcover vegetation. Planting is into a 30° inclined soil bed over a geotextile which is underlain by rock fill of various sizes. Berms are at 15 m vertical intervals on the slope face, separated by a 60° to 70° steep rock face (Details overleaf).

Close-up views of the rehabilitated quarry face are considered to be visually acceptable. However in long-range views the rock face is clearly visible but this should improve with time as the climbers become established.

Landscaping at a major quarry. The process of re-vegetation.

Landscaping Procedures for a Typical 10 m Bench:

1. Formation of final landform by the blasting technique of "pre-splitting".
2. Formation of mortared rock support.
3. Construction of U-channel.
4. Formation of maximum 30º rock fill slope (shot rock).
5. Placement of 150 mm thick filter layer of rip-rap aggregates on the surface of the rock fill slope.
6. Laying of 600 mm thick completely decomposed granite (CDG) soil layer with its top 150 mm mixed with soil container and fertilizer for the forming of planting medium.
7. Placement of permanent nylon geotextile to prevent soil erosion.
8. Planting of grasses, shrubs and trees.
9. Establishment of landscape planting.



13. Turret Hill Ex-Quarry at Shatin

The Turret Hill Ex-Quarry is located to the northeast of Shatin New Town and covers about 25 ha of land. The site was established in the 1960s for the extraction of rock fill. GEO appointed Binnie and Partners to design a restoration plan for the quarry including construction of stable quarry face and quarry floor.

The quarry faces, which were originally 60º to 70º, were trimmed to a series of benches some 20 m high and at about 50º giving an overall slope angle of about 40º. The final rock faces are purposely made rough with ledges and crevices by control–blasting in order to retain soil and moisture for vegetation. Initially, berms were planted with vegetation and trees according to the original design, however it was found that some tree species could not survive. After negotiations between the engineer and landscape architect, it was decided to put soil bags at specific locations marked on site, and not to replace the dead vegetation with the originally proposed species. As a result, hardy local species colonised the soil bags and a 'natural' self-sustaining flora became established.

The restoration work is regarded as "one of the greatest achievements of the Mines and Quarry Division of GEO". The engineer-in-charge is satisfied that a self-sustained vegetation system has established and successfully blends with the natural environment. The engineer carefully supervised and observed the vegetation and is convinced that the natural selection process can establish a self-sustaining environment.

14. Hong Kong City Polytechnic (University)

The study site is a retaining wall, slope No. 11NW-B/CR601 (wall only), located at Hong Kong City Polytechnic (University), Kowloon Tong. The wall was built in 1988 to provide space for new building. Mitchell McFarlane Brentnall and Partnership was appointed by City Polytechnic with landscape sub-consultant EBC (Hassell) to carry out the design and construction works.

Limited space was the principal constraint to the design. Different types of retaining wall were considered, but it was finally decided to use a crib wall which reduced the amount of cutting and provided a good visual appearance. In every fifth layer of concrete and compacted soil, a layer of topsoil was laid for planting. The topsoil was mixed with "jelly" which absorbs water in the wet season and releases water in dry season. The construction was supervised by a resident engineer, a resident architect and a part-time landscape architect.

The designer is satisfied with the end product, especially the 76^{o} gradient that is different from the traditional vertical retaining wall. Growing vegetation in a crib wall provides a greening effect that blends with the surroundings. The design required good teamwork, with the engineer keen to build a visually pleasing wall and involve the landscape architect at an early stage. The whole process was facilitated by support and awareness from the Client and by the resident architect' s familiarity with landscaping requirements.

15. Below Cape Collinson Crematorium

The study site, slope No. (11SE-D/F19), is located below the Cape Collinson Crematorium, Chai Wan. The slope was included in the 1995/1996 LPM programmes. Halcrow Asia Partnership Limited were appointed by GEO to carry out the upgrading of the slope. Urbis Limited and Pegasus Greenland Limited were landscape sub-consultant and landscape contractor respectively.

The objective of the work was to upgrade the slope to current standards. Among three options proposed in the Option Assessment Report, an option using a reinforced soil block at the toe of the improved area and recompaction of slope fill was selected. The major constraints were the feature geometry and the proximity of the Crematorium above. The landscape sub-consultant was involved after the issue of the general arrangement drawings. The landscape design proposed hydroseeding on the slope, with mixed woodland planting at whip size. The reinforced soil wall at the toe of the slope was hydroseeded and planted with climbers which provided a strong greening effect to the base of the slope. Heavy standard trees were to be planted on the newly formed fill platform at the top of the slope for more immediate effect and to provide a screen for activities within the Crematorium. Two existing *Auracaria heterophylla* were retained by transplantation as these were seen as important to the overall character of the Crematorium. Because of the difficulties of transplanting these big trees, it was decided to retain the trees at the original position by retaining walls. Due to the higher than expected rockhead, the proposed reinforced soil block at the toe was replaced with a buttress but the landscape design remained otherwise unchanged. During the construction, a resident engineering team and the landscape officer supervised the works. The landscape officer visited the site on regular basis to check landscaping work and to give landscape advice.

The finished slope is considered a success in terms of visual impact with a number of favourable comments being received from concerned individuals and organisations.

16. No. 9A Bonham Road

The study feature, retaining wall No. 11SW-A/R544, is situated immediately to the north of No. 9A Bonham Road. It is an old masonry wall that is about 8 m high and 200 m long with a rendered parapet at its crest. Some mature trees with extensive root networks are established on the face of the wall. The feature was selected by the GEO for inclusion in the 1995/1996 LPM Programme.

To upgrade the wall, three design options were proposed, with a principal objective being to retain the mature trees on the wall face. The required improvement in the margin of safety in this case was relatively small and the preferred solution was to construct stone faced concrete buttresses at specific locations along the wall. This option was chosen because of the minimal visual impact and disturbance to existing mature vegetation and the relative simplicity of construction. Landscape architects were consulted during the design stage, to assist with incorporating preservation of the mature trees into the design. Tree surveys were conducted and several trees were selected for preservation based on appearance, maturity and rarity of the species. Buttresses were subsequently constructed between the preserved trees, with little or no change in the basic design of the buttresses. During construction, the landscape architects had limited involvement, but a landscape field officer was available for a few hours to provide advice on minor transplanting and re-planting works, trimming of the root networks and maintenance of planting. Works were supervised by engineering RSS.

The finished product is considered as a success in terms of visual and ecological impact, and the design process was a good example of co-operation between engineer and landscape architects. In this case, a major factor was the accurate judgement of the amount of stabilisation work required. As the required improvement to the stability of the wall was comparatively small, there was more flexibility to allow consideration of visual and ecological factors in the engineering design.

17. Gascoigne Road

The study feature at Gascoigne Road, retaining wall No. 11NW-D/R255, was constructed during a project that was completed in 1988 to extend the flyover crossing Wylie Road. The wall is about 15 m high and is decorated with pre-cast concrete pattern panels (2 m x 2 m) which have graphic surface designs. A planter with mixed ornamental trees and shrubs is located at the toe of wall. Shui On Civil Engineering Ltd and a French Company, Rousette, were the main contractor and the nominated sub-contractor respectively.

Landscape and engineering issues were considered in parallel during design as Highways Department, for whom the flyover extension project was carried out, were concerned that the new wall should have a pleasing appearance. Accordingly the pre-cast concrete panel solution, which was new to Hong Kong, was the preferred solution. Limited space at the crest of the slope due to the proximity of the Queen Elizabeth Hospital Nurses Quarters and pollution and low light levels associated with the heavily trafficked road and existing flyover were the principal constraints to the design. Before the construction of the retaining wall, a trial was undertaken on a free-standing wall to test and select the most suitable pre-cast method. Rib patterns in the panel design were arranged diagonally to direct running water and minimise water stain and prevent accumulation of dust. The coping at the top of the retaining wall was also angled backwards to prevent dust accumulation and facilitate draining of water. An earthy colour was used because it is considered to be a long lasting colour and has a lower reflectivity than plain concrete. Toe planters, designed by the landscape architects of Highways Department, were also built to take small trees and provide an ornamental effect. Landscape architects inspected the construction of the wall and were also involved in the pre-cast concrete panel-making process to ensure the consistency of the panel colour.

The landscaping treatment of the wall required close co-operation between engineer and landscape architect and is widely regarded as a success. The panel trials were also valuable in controlling the quality of the work, which used materials and techniques new to the HKSAR. It is felt that more complex patterns such as pre-made formwork could have been considered if the landscape architect had been involved in the engineering design.

APPENDIX C

RESULTS OF OPINION SURVEYS

QUESTIONNAIRE FOR PROJECT ENGINEERS INVOLVED IN LPM DESIGN WORKS

This questionnaire is part of a GEO study to review the use of landscaping on man-made slopes and retaining walls. Your own opinions are important.

Date:
Engineer's Name:
Company Name:
Telephone No.:

In your opinion, how important would you consider the following factors in designing a slope/retaining wall? (Please circle the relevant option)

	Least important						Most important
Safety	Not considered	1	2	3	4	5	6
Cost	Not considered	1	2	3	4	5	6
Maintenance	Not considered	1	2	3	4	5	6
Visual Impact	Not considered	1	2	3	4	5	6
Ecology	Not considered	1	2	3	4	5	6
Other(s) _____	Not considered	1	2	3	4	5	6

Generally, in your experience, how successful do you consider the following factors are in finished slopes/retaining walls? (Please circle the relevant option)

	Not successful					Very successful
Safety	1	2	3	4	5	6
Cost	1	2	3	4	5	6
Maintenance	1	2	3	4	5	6
Visual Impact	1	2	3	4	5	6
Ecology	1	2	3	4	5	6
Other(s) _____	1	2	3	4	5	6

Do you consider landscaping treatment during design? *Always / Often / Sometimes / Seldom / Never* (Please circle the most relevant option) Please give example if possible.

At what stage of design do you consider landscaping treatment: *Early / Middle / Late / Not at all* (Please circle the most relevant option)

Do you normally employ a landscape specialist? *Always / Often / Sometimes / Seldom / Never* (Please circle the relevant option)

Do you consider the existing landscaping slope guidelines are *sufficient / moderately sufficient / not sufficient*. (Please circle the most appropriate option) Please discuss if possible.

Do you consider alternative landscape treatments in your designs? *Yes / No* (Please circle the relevant option)

Table C1 - Companies included in Opinion Survey

Company	Date Responded	No. of Questionnaires
Hyder Consulting Ltd.	5-Feb-99	5
Babtie BMT Harris & Sutherland	9-Feb-99	2
Binnie Black & Veatch HK Ltd.	8-Feb-99	5
ESA Consulting Engineers Ltd.	2-Mar-99	1
Fugro (HK) Ltd.	5-Feb-99	4
Halcrow Asia Partnership	5-Feb-99	5
Atkins China Ltd	5-Feb-99	4
Maunsell Geotechnical Services Ltd	4-Feb-99	3
Mouchel Asia Ltd	1-Feb-99	1
Ove Arup & Partner HK Ltd.	2-Feb-99	2
Scott Wilson (HK) Ltd	5-Feb-99	4
SMEC Asia Ltd.	29-Jan-99	3
Design Division/GEO	4-Feb-99	18
	TOTAL	57

Table C2 - Factors Considered by the LPM Engineers in Designing

Factors		Not considered	Least important ------>Most important						Total No.
			1	2	3	4	5	6	
Safety		0	0	0	1	0	4	52	57
Cost		0	0	0	1	21	35	0	57
Maintenance		0	0	0	4	21	26	6	57
Visual Impact		0	0	1	6	36	13	1	57
Ecology		2	4	8	11	23	7	0	55
Others:	Construction time	-	-	-	1	-	-	-	1
	Construction feasibility	-	-	-	-	2	1	2	5
	Client's requirement	-	-	-	-	1	-	1	2
	Comments from other parties	-	-	-	-	1	-	-	1

Table C3 - Success of Finished Slopes Considered by LPM Engineers

Factors		Least successful ------>Most successful						Total No.
		1	2	3	4	5	6	
Safety		0	0	0	4	22	31	57
Cost		0	1	4	19	29	4	57
Maintenance		0	0	11	17	23	6	57
Visual Impact		3	5	15	22	11	1	57
Ecology		8	6	19	18	3	1	55
Others:	Construction time	-	-	-	-	-	1	1
	Construction feasibility	-	1	-	-	1	-	2
	Client's requirement	-	-	-	-	1	1	2
	Comments from other parties	-	-	-	1	-	-	1

Table C4 - Consideration of Landscape Treatments during Design

Considering landscaping	No. of response
Always	30
Often	19
Sometimes	7
Seldom	1
Never	0
TOTAL	57

Table C5 - Landscaping Treatments Considered at Different Stage of Design

Stage consider landscaping	No. of response
Early	22
Middle	24
Late	11
Not at all	0
TOTAL	57

Table C6 - Employment of Landscape Specialists

Employment of landscape specialists	No. of response
Always	15
Often	13
Sometimes	15
Seldom	8
Never	6
TOTAL	57

Table C7 - General Viewpoint on the Existing Slope Guidelines

Existing slope guidelines	No. of response
Sufficient	2
Moderately sufficient	20
Not sufficient	34
TOTAL	56

Table C8 - Consideration of Alternative Treatments in Design

Alternative treatment design	No. of response
Yes	47
No	10
TOTAL	57

QUESTIONNAIRE FOR LANDSCAPE PRACTITIONERS

This questionnaire is part of a study commissioned by the Geotechnical Engineering Office of Hong Kong Government to review the use of landscaping on man-made slopes and retaining walls.

Your opinions are important, and will be collated with those of officers from Government Departments, the Hong Kong Institute of landscape Architects and Private Practices, to form a professional view point on the visual problems associated with slopes and to develop ideas on the best way forward. Separate questionnaires have been sent to members of the engineering profession, contracting organisations and concerned environmental groups. Surveys of public opinion will also be conducted.

Respondents details	
Name : *Organisation* *Designation:* *Date:*	

How important is the landscape treatment of slopes and in determining the overall quality of the visual environment in HK ?	a little					a lot
in urban areas	1	2	3	4	5	6
in rural areas	1	2	3	4	5	6

How important should the following factors be in the design of slopes and retaining walls ?	a little					a lot
cost	1	2	3	4	5	6
safety	1	2	3	4	5	6
appearance	1	2	3	4	5	6

How much do you think the following influences the appearance of slopes and retaining walls ?	a little					a lot
overall size / scale	1	2	3	4	5	6
composition	1	2	3	4	5	6
gradient and profile	1	2	3	4	5	6
choice of colour	1	2	3	4	5	6
texture and patterning	1	2	3	4	5	6

How much improvement in the appearance of slopes and retaining walls do you think could be achieved by spending extra public money on the following?	a little					a lot
retention of existing trees	1	2	3	4	5	6
retention of natural rock surfaces	1	2	3	4	5	6
addition of colour to spray concrete surfaces	1	2	3	4	5	6
addition of patterns in concrete structures	1	2	3	4	5	6
use of cladding, tiling or artwork to hide concrete structures	1	2	3	4	5	6
treatment of drainage channels and pipes	1	2	3	4	5	6
incorporation of more planting beds for shrubs and climbers	1	2	3	4	5	6

To what extent to you consider the poor visual quality of some slopes is attributable to any of the following ?	a little					a lot
insufficient funding of landscape works	1	2	3	4	5	6
landscape input coming too late in the design process	1	2	3	4	5	6
landscape not being given sufficient priority in the design process	1	2	3	4	5	6
poor landscape design	1	2	3	4	5	6
lack of integration between landscape and engineering designs	1	2	3	4	5	6
lack of control over design changes on site	1	2	3	4	5	6
lack of supervision of landscape works	1	2	3	4	5	6
poor quality of materials and workmanship in landscape works	1	2	3	4	5	6

Open Question 1. Given site, programme and budgetary constraints on design, how would you judge success or failure in the landscape treatment of a slope / retaining wall feature ? i.e. What parameters would you use to define the optimum landscape solution ?

Open Question 2. How should landscape and visual factors be taken into account in the design of slope features ?

Open Question 3. Do you have any other comments or opinions on the visual treatment of slopes and retaining walls, which you think might be useful to this study?

Table C9 - Details of Response

Company	Date Responded	No. of Questionnaire Received
SLA/Housing Authority	22-Mar-99	1
SLA/TDD	23-Mar-99	1
Highways Department	8-Apr-99	6
Urbis Ltd.	12-Apr-99	1
EDAW Earthaisa Ltd.	13-Apr-99	1
Urban Design & Landscape Planning Units	13-Apr-99	1
*ACLA Limited	21-Apr-99	1
Architectural Services Department	26-Apr-99	14
	TOTAL	26

Note: * Represents combined response.

Table C10 - Importance of Landscape Treatment on Slopes in Urban and Rural Areas in Determining Overall Quality of the Visual Environment

Setting	a little ---------- a lot						Total No.
	1	2	3	4	5	6	
In urban areas	0	0	0	2	5	19	26
In rural areas	0	0	0	2	7	17	26

Table C11 - Importance of Cost, Safety and Appearance in Designing Slopes and Retaining Walls

Factors	a little ---------- a lot						Total No.
	1	2	3	4	5	6	
Cost	1	2	3	13	6	1	26
Safety	0	0	1	0	3	22	26
Appearance	0	0	0	2	13	11	26

Table C12 - Importance of the Following Factors Influencing the Appearance of Slopes and Retaining Walls

Factors	a little ---------- a lot						Total No.
	1	2	3	4	5	6	
Overall size / scale	0	0	0	1	5	20	26
Composition	0	1	1	4	11	9	26
Gradient and profile	0	2	2	6	8	8	26
Choice of colour	0	0	2	6	11	7	26
Texture and patterning	0	0	4	4	11	7	26

Table C13 - Improvement in Appearance of Slopes and Retaining Walls by Spending Extra Money on the Following Factors

Factors	a little ---------- a lot						Total No.
	1	2	3	4	5	6	
Retention of existing trees	0	0	1	2	2	21	26
Retention of natural rock surface	0	0	0	3	8	15	26
Addition of colour to spray concrete surface	2	3	5	9	4	3	26
Addition of patterns in concrete structures	0	2	6	10	7	1	26
Use of cladding, tiling or artwork to hide concrete structures	0	0	8	8	8	2	26
Treatment of drainage channels and pipes	1	1	4	10	6	4	26
Incorporation of more planting beds for shrubs and climbers	0	0	0	0	10	16	26

Table C14 - Extents of the Following Factors Lead to Poor Visual Quality of Some Slopes

Factors	a little ---------- a lot						Total No.
	1	2	3	4	5	6	
Insufficient funding of landscape works	2	1	7	7	5	4	26
Landscape input coming too late in the design process	0	0	0	2	5	19	26
Landscape not being given sufficient priority in the design process	0	0	1	2	3	20	26
Poor landscape design	3	4	6	5	5	3	26
Lack of integration between landscape and engineering design	0	0	3	5	6	12	26
Lack of control over design changes on site	1	2	5	10	8	0	26
Lack of supervision of landscaping works	2	4	6	7	4	3	26
Poor quality of materials and workmanship in landscaping works	1	4	8	4	6	3	26

SUMMARY OF ANSWERS TO THE OPEN QUESTIONS

Question 1

Most interviewees define the optimum landscape solution as a compromise between development and landscape. A visual integration between slope and the surroundings would be a successful landscape treatment. The establishment of planting should blend into the existing vegetation to create a naturalistic slope design. All landscape solutions should become a source of positive visual interest locally.

Question 2

Landscape and visual factors should be integrated into all stages of the process, i.e. planning, design and construction of landscape treatment. Landscaping should avoid unnecessary cutting and promote preservation of existing trees as far as possible. Slope treatment should minimise the visual impacts on residents and travellers. Methods like hydroseeding and planting are recommended for gentle slopes, while for steep slopes, well-designed retaining walls are seen as the best way to reduce visual impact on ground level viewers.

Question 3

Other useful opinions made by interviewees:

1. Suggest using bio-engineering techniques to stabilise the slope.
2. Problem of shotcrete is very common in Hong Kong.
3. The slope design process is poorly integrated. Usually landscape architects only participate in the final stage of the process and take the role to ' green up' the engineering solution. Sufficient budget should be provided to ensure participation of landscape architects at planning, design and construction stages.

APPENDIX D

SUMMARY OF PAPERS PRESENTED IN RECENT ASIAN CONFERENCE ON GROUND AND WATER BIO-ENGINEERING FOR EROSION CONTROL AND SLOPE STABILIZATION, MANILA 1999

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 1 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
Australia	Vetiver Grass - Surface erosion control	Planting of Vetiver grass on a slope.	Rehabilitation of old quarry, stabilise coal and gold mines in Queensland.	Truong (1999)	• good short term surface erosion control • allows other plants to become established • highly tolerant of poor ground conditions	• can be short lived • requires high levels of maintenance in initial stages • does not reproduce so can not form part of a ecological succession • commercially produced therefore expensive • no technical data to support suppliers claims • has been known to concentrate washout
Bangladesh	Broom grass (*Thyansolaena maxima*) hedge	Planting of broom grass on gentle to steep hillside slopes. Grass has a strong underground rhizome system which reduces soil erosion.	Grow on cut slope or very steep sloping land for soil preservation.	Khisa et al (1999), Shoalb et al (1999)	• already grows in Hong Kong and could be adapted for use	• no scientific data
	Jute geo-textile (JGT)	JGT laid on landslide devasted area to protect bare debris, facilitate vegetation and increase organic matter by self-decomposing.	Stabilisation of landslide area, re-vegetation of degraded area.		• inexpensive • easy to install and plant through • bio-degradeable so won't restrict future plant growth	• no scientific data • possible inconsistency in material quality • heavy to transport • possibly bio-degrades too quickly

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 2 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
Caribbean region	Live mini check dam	Constructed from live plants and locally available materials.	Prevent rill development. Repair small gullies. Strengthen natural drainage channels at culvert and side drain outfall sites.	Clark and Hellin (1996)	• inexpensive • good landscape appearance	• no scientific data • lack of suitable plant material • limited range of plant species suitable for the use • needs wet soils to root
	Fascines	A fascine forms a dense hedge which is established on the contour of the slope from material which has the capacity to propagate from horizontally placed hardwood cuttings.	Strengthen gullies and vulnerable areas. Protect drains. Stabilise fill slopes.		• Currently used in PRC as gully erosion control method • inexpensive • good landscape appearance	• no scientific data • lack of suitable plant material • limited range of plant species suitable for the use • needs wet soils to root
	Stone pitching with vegetation	A layer of stones, cobbles and small boulders.	Protect the toe of slope, base of a gully (maximum gradient of 30°).		• Similar techniques currently used in HK • good surface erosion control	• expensive • can be unsightly • can restrict plant growth
	Grass barrier silt trap	Provide an effective way of preventing material moving down slope from entering a drain or waterway.	Use above side drains, cut off drains, around culverts or catch pits. Same technique as Vetiver		•	• may need high level of irrigation fertiliser in initial stage

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 3 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
	Vetiver Grass - Surface erosion control	A dense planting of Vetiver grass across a slope.	Protect roadside slopes, rehabilitate failed cut slopes, revegetate fill slopes. Use at the junction of a ridged engineering structure such as masonry check dam, retaining wall.		same as for Vetiver	same as for Vetiver
	Dry stone toe wall with vegetation	To strengthen the toe of the slope preventing erosion and undercutting which can lead to gradual retreat of the slope.	Use at the base of cut slopes or consolidated fill slope. Not suitable for unconsolidated loose fill slope. Protect the side drain.		• similar techniques used in HK • used as part of a composite scheme to protect undercutting	• more applicable to stream banks / revetments
China	Hydroseeding	Seed, fertilisers, mulch and binder are mixed into slurry with water, and sprayed on the slope.	Establish vegetation on roadside slopes in southwest of China.	Jiang et al (1999), Truong (1999), Xia et al (1999)		
	Vetiver Grass – Surface erosion control	Planting of Vetiver grass on slope.	The method has applied to slopes in Nanjing, Guangzhou and Fujian for soil erosion control.		same as for Vetiver	same as for Vetiver
India	Geofabrics (Jute and Coir nets)	Net laid on slope surface.	Jute and Coir nets have been used for erosion control on hill slopes and highway embankments.	Sarin et al (1999)		

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 4 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
Japan	Terracing and planting	Hillsides are terraced, grass is planted on the steep slope, black pine and Alnus (1:2) are planted on the platform.	Applied to weathered granite mountains in western part of Japan.	Mizuyama et al (1999)	• inexpensive materials • establishes a good vegetation cover	• requires detailed site formation works • involves locally oversteepened slopes which may be unstable • may have long term management requirements
	Biobarrier	A root control system made of geotextile fabric with permanently attached nodules containing trifluralin, a chemical, which prevents root tip cell division.	Biobarrier has been used for protecting roads and underground utilities from the penetration of tree roots by laying or wrapping barrier on the protected objects.	Brochures provided by BBA Nonwovens Asia Pacific Ltd. (1999)	•	•
Korea	Hydroseeding	Seed, fertilisers, mulch and binder are mixed into slurry with water, and sprayed on the slope surface under pressure.	Applied to man-made rock cut-slopes due to highway construction through the mountainous area.	Kim et al (1999), Woo et al (1999)	• can be used on very steep slopes to provide green effect	• has long term management requirements, especially watering • may not form a secure bond with the rock beneath, and maybe subject to typhoon damage
	Turf	Surface covered with sods of turf.	Applied to road slopes in Korea.		• standard technique Hong Kong, using local species	• suitable only for soil slopes below about 30 degrees

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 5 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
	Artificial soil patching	Localised use of 'artificial soil' on rock slope to grow vegetation cover.	Applied to rock slope in Korea to prevent weathering of surface and to establish vegetation.		•	• separation of artificial soil layer from rock surface due to shrinkage of soil • Limited scientific data available
	Co-Mat	The method uses material mixed with wood fibre, seed, cement, sawdust and water.	Applied to road slopes in Korea. Periodical water spray is required during dry season. vegetable matting impregnated with grass (other) seeds similar products already used in HK		• has previously been used in HK • relatively inexpensive • useful way of applying larger sized seeds (that can't be hydroseeded) • can protect from light surface erosion forces	• limited to relatively even soil slopes, possibly up to 45 degrees • needs high level of initial maintenance • potential damage by heavy rain and high wind in early stages • variable quality, particularly in rate of bio-degradation
	Coir Net	Net is used to cover seeds.	Applied to road slopes in Korea. similar products already used in HK		• inexpensive • easy to install and plant through • bio-degradeable so won't restrict future plant growth	• no scientific data • possible inconsistency in material quality • possibly bio-degrades too quickly

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 6 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
	Coir carpet	Major material is composed of coconut fibre which combines coconut fibre with a photodegradable structure mesh. The method uses biodegradable matting, and is also available in mulch-mat form to control unwanted vegetation.	This is a new method in Korea that modified the existing slope protection method. similar products already used in HK		• inexpensive • heavy grade carpets can be difficult to plant through • bio-degradeable so won't restrict future plant growth	• no scientific data • possible inconsistency in material quality • heavy to transport
Malaysia	Vetiver Grass - Surface erosion control	Planting of Vetiver grass on a slope.	Applied for erosion and slope stabilisation in highway engineering.	Truong (1999)	same as for Vetiver	same as for Vetiver
Nepal	Planted grass line: contour/ horizontal	Grass slips, rooted stem cuttings or clumps grown from seed are planted in lines across a slope (≤ 65°).	Protect the slope with roots and, by providing surface cover, reduce the speed of runoff and catch debris, thereby armouring it.	Geo-Environmental Unit (1997), Howell et al (1991, 1999)	same as for Vetiver • contour planting helps minimise gully erosion	• may be prone to washout if terraces do not drain
	Planted grass line: downslope/ vertical	Grass slips, rooted stem cuttings or clumps grown from seed are planted in lines running down the slope (≤ 65°).	A slope is allowed to develop a semi-natural drainage system, gullying in a controlled way. Not for catching debris.		• subject to gully erosion	

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 7 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
	Planted grass line: diagonal	Grass slips, rooted stem cuttings or clumps grown from seed are planted in lines running diagonally across the slope ($\leq 65^{o}$).	Limited functions of catching debris and draining surface water. Offer compromise of the grass line planting systems.			
	Planted grasses: random planting	Grass slips, rooted stem cuttings or clumps grown from seed are planted at random on a slope ($\leq 50^{o}$), to an approximate specified density.	Limited function of catching debris. Commonly used in conjunction with standard mesh jute netting, where complete surface protection is needed on very steep, harsh slope.		• consistency of effect may be a problem	
	Turfing	Surface covered with sods of turf brought from elsewhere. (Slope $\leq 35^{o}$)	Gives complete and instant armouring.		• commonly used in HK for slopes less than 30 degrees • requires high level of maintenance • ecologically not self sustaining	• good aesthetic effect
	Shrub and tree planting	Seedlings of shrubs and trees are planted at intervals throughout a site.	Feasible only on less steep slopes. Grow to reinforce and anchor the slope.		• commonly used in HK for slopes which can support body of soil	
	Shrub and tree seeding	Seeds of shrubs and trees are inserted into cracks on steep, rocky slopes. Can also be broadcast over a site.	Grow to reinforce and anchor the slope.		• has been used in HK for rock faces	

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 8 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
	Large bamboo planting	Large clumping bamboos are planted on a site.	Clumps provide reinforcement and support to the slope.		same as for Vetiver	
	Brush layering	Woody (or hardwood) cuttings are built to form a live check dam.	Form a strong barrier to slow the development of rills. Trap material moving downwards.		• traditional slope stabilisation technique • inexpensive • good landscape appearance	• no scientific data • lack of suitable plant material • limited range of plant species suitable for the use • needs wet soils to root
	Palisades	Woody (or hardwood) cuttings are planted across a slope, usually following the contour.	Form a barrier to slow the development of rills. Trap material moving downwards.		same comments as brush layering	same comments as brush layering
	Live check dams	Woody (or hardwood) cuttings are built to form a live check dam.	Armour and reinforce gullies. Trap material moving downwards.		same comments as brush layering	same comments as brush layering
	Fascine constructions	Bundles of live branches are laid in trenches across a slope, usually following the contour.	Form a strong barrier to prevent the development of rills and trap material moving down the slope.		same comments as brush layering	same comments as brush layering
	Wire bolster cylinders	Laid into trenches in the slope.	Form a barrier to slow the development of rills and trap materials moving down the slope.		• opportunities for plants to grow	• expensive • no scientific data • difficult to install

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 9 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
	Vegetated stone pitching	Combination of dry stone walling or cobbling, and vegetation planted in the gaps between the stones.	Provide strong form of armouring. Reinforce toe walls. Protected gully beds.		similar to comments made on Dry stone toe wall with vegetation	
	Jute netting (standard mesh)	A geotextile of woven jute netting (~40 x 40 mm) is placed on the slope.	Protect surface, armouring against erosion and catching small debris. Allow seeds to hold and germinate. Improvement of microclimate on the slope surface by holding moisture and increasing infiltration. Act as a mulch for the vegetation established as it decays.		similar to comments made on Coir Mat	
	Jute netting (wide mesh)	A geotextile of woven jute netting (~150 x 450 mm) is placed on the slope.	Hold mulch on slopes that have been seeded.		similar to comments made on Coir Net	
Philippines	Vetiver Grass – Surface erosion control	Planting of Vetiver grass on slope.	Applied to slopes of Subic Freeport Expressway for soil erosion.	Chant et al (1999), Tan et al (1999), Truong (1999)	same as for Vetiver	same as for Vetiver

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 10 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
	Planting on slope	Planting of selected vegetations e.g. trees, shrubs, grasses or bamboos.	Slopes on Halsema Highway are in extreme conditions which requires that plant species be hardy, indigenous, easily propagated, drought resistant and with strong, deep root systems.			
South Africa	Vetiver Grass - Surface erosion control	Planting of Vetiver grass on a slope.	Applied to mine rehabilitation.	Truong (1999)	same as for Vetiver	same as for Vetiver
Taiwan	Vegetation belt (Mat)	Slope surface is covered with vegetation belt which is made of artificial fibre, natural fibre (or mix) and plant seeds in net.	Applied to mudstone area.	Lin and Chang (1999)	similar to comments made on Vetiver	not a proprietary technique, therefore possibly inexpensive
	Fertnet method	Soft and anti-erosive unwoven cloth (with longitudinal bags filled with peat, organic fertilisers and vegetative materials) is laid on slope surface.	Applied in mudstone area.		similar to comments made on Coir Net	

Table D1 - Summary of Papers Presented in Recent Asian Conference on Ground and Water Bio-engineering for Erosion Control and Slope Stabilization (Sheet 11 of 11)

Country	Technique		Application	Source (note 1)	Suitability to Hong Kong Conditions	
	Name	Description			Advantages	Limitations
	Staking and Stainless Wattling	Set up steel stake with unwoven cloth. Borrowed soils are brought in to form a platform to support vegetation.	Applied in mudstone area.		similar to comments made on Fascines • more scientific, more predictable results than vegetable fascines	• non-bio-degradeable element may have long term effect on plant growth • expensive
Thailand	Vetiver Grass – Surface erosion control	Planting of Vetiver grass on a slope.	Roadside stabilisation with Vetiver Grass has been applied to northern regions of Thailand.	Truong (1999)	same as for Vetiver	same as for Vetiver

Note: (1) For sources see International Erosion Control Association (1999).

APPENDIX E

LIST OF PROPRIETARY PRODUCT DETAILS

PROPRIETARY PRODUCTS DATABASE

SUMMARY SHEET

INTRODUCTION

The enclosed information contains a database of proprietary products used in slope landscape treatments and formation provided by suppliers/agents. The range of products includes reinforcing geotextiles, erosion control mats, drainage geotextiles, vegetation establishment and control products, modular wall systems and slope surfacing systems. This information was compiled as part of Consultancy Agreement No. GEO 9/98 "Review of Effective Methods of Integrating Man-made Slopes and Retaining Walls (Particularly for Roadside Slopes) into Their Surroundings" with the Civil Engineering Department.

The database comprises the following items.

(a) This Summary Sheet. This provides a brief explanation to the structure of the database and conditions for the user.

(b) Contact List of Suppliers/Agents and Products (Table E1). Contains company names, addresses, contact persons, telephone and fax numbers, E-mail addresses and products of suppliers/agents presented alphabetically by company name.

(c) Summary Tables of Proprietary Products. The summary tables are divided into 2 tables, namely products that have been used in Hong Kong (Table E2), and products that have not been used in Hong Kong (Table E3). Within each table, product details are presented alphabetically by product name. The summary tables are also included in digital format using MS Excel spreadsheet software version 6.0 for Windows 95 on a 3½" floppy disc.

(d) Brochures/Catalogues. Copies of trade catalogues or brochures of each proprietary product provided by the suppliers/agents, together with any supplementary correspondence, giving detailed information such as technical specification, installation and performance data.

IMPORTANT NOTES TO READERS

1. All information is provided by the suppliers/agents. No interpretations have been made.

2. Capital cost is the estimated cost which includes installation, materials and other cost involved in installation of the product/technique, unless otherwise stated.

3. Recurrent cost is the estimated yearly maintenance cost.

4. Both capital and recurrent costs as provided by the suppliers/agents are for guidance only. Please contact the corresponding suppliers/agents for an exact quote.

5. A few of the products mentioned in the brochures are not included in the summary tables. Please contact the suppliers/agents for details.

6. Information in the summary tables is up to August 1999.

Table E1 - Contact List of Suppliers/Agents and Products (Sheet 1 of 4)

Supplier / Agent	Contact Address / Nos.	Contact Person	Products
Apex (Asia-Pacific) Pty Ltd.	Exchange House, 6/F 68 St. Georges Terrace Perth W.A. 6000 Australia Tel: (618) 9226 2220 Fax: (618) 9226 2221	Martyn Smith	Coir Erosion Control Blankets Permacrib Soil Panel Terra Cell Terra Drain Terra Grid
Aspinwall & Co Ltd	Aspinwall Group Aspinwall House Cochin – 682 001 India Tel: (+91) 484 224449 Fax: (+91) 484 224469 E-mail:crrvarma@vsnl.com	C R R Varma (Managing Director)	Natural Fibre Geotextile
BBA Nonwovens Asia Pacific Ltd.	Rm 1714, Aerospace Tower, Concordia Plaza, 1 Science Museum Road, TST East, Kowloon Tel: 2620 5677 Fax 2620 5662 E-mail: mikewong@bba-nonwovens.com.hk	Micheal Wong (General Manager)	Biobarrier
BBA Nonwovens – Reemay, Inc.	70 Old Hickory Blvd., P.O. Box 511, Old Hickory, TN 37138-3651 Tel: (+1) 615 847-7075 Fax: (+1) 615 847-7068 E-mail: reemay@worldnet.att.net	Ms. Webster (Intl. Business Unit Manager)	Biobarrier
Bonterra Weiland GmbH	Kermeterstr. 10 52385 Nideggen Germany Tel: (+49) 2427 437 Fax: (+49) 2427 1204	Mr Ingrid Weiland (Managing Director)	Permacrib
Bumatech	Room 1511-13 Grand Century Place Tower I 193 Prince Edward Road Mongkok Kowloon Tel: 2311 1123 Fax: 2723 6019 Web: http://www.bumatech.com	Miss Tristy Wong	Forta Concrete Manta Ray Miradrain Mirafi Geotexiles Miragrid Geogrid Miramat
Comtec Civil Engineering Limited	Bells Yew Garden Tunbridge wells Kent TN3 9BQ UK Tel: +44 (0) 1892 750664 Fax: +44 (0) 1892 750662	Jerry Fox Managing Director	Hydroseed with Seanure Soilbuilder Tensar Wall Blocks Textomur Green Textomur for Nailing Textomur Stone Timbacrib

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf)

Table E1 - Contact List of Suppliers/Agents and Products (Sheet 2 of 4)

Supplier / Agent	Contact Address / Nos.	Contact Person	Products
Constructional Systems Ltd	14/F Tai Po Commercial Centre 152 Kwong Fuk Road Tai Po NT Tel: 2656 6488 Fax: 2651 6808	Victor Yuen	Gabions Reno Mattresses Tensar Wall Blocks
Doran (HK) Ltd	Ground Floor Grammy Centre 238 Yee Kuk Street Sham Shui Po Kowloon Tel: 2674 2324 Fax: 2360 6782	Marketing Executive	Doran I.C.B. Crib Wall
Fastman International Ltd	Room 85 8/F New Henty house 10 Ice house Street Central Hong Kong Tel: 2868 6855 Fax: 2522 8603	Miss Anthea Y Tang	Grassguard Recyfix Turf-Honeycomb Revetlok
Grass Concrete International Ltd	Walker House 22 Bond Street Wakefield W Yorkshire WF1 2QP UK Tel: +44 (0) 1924 375997 Fax: +44 (0) 1924 290289	R E Howden Managing Director	Grasscrete
Hy-Tex (UK) Ltd	P O Box 97 Aldington Ashford Kent TN25 7EA UK Tel: +44 (0) 1233 720097 Fax: +44 (0) 1233 720098 E-mail: sales@hy-tex.co.uk	Mike Hyder (Managing Director)	Coconut Meshes Coirmesh Soil Saver Jute Mesh
Jacobson van den Berg (Far East Ltd.)	237 Lockhart Road Wanchai Hong Kong P.O. Box 20279 Henessy Road Post Office Hong Kong	Marco Kwok	Erosion Control Blankets Hastec Erosion Constrol System – Erosion Control Fibre
L F Sam (HK) Ltd	7/F First Commercial Building 33-35 Leighton Road Hong Kong Tel: 2891 8488 Fax: 2834 5283 or 2836 0134	Marketing Executive	Atlantis Drainage Cells

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf)

Table E1 - Contact List of Suppliers/Agents and Products (Sheet 3 of 4)

Supplier / Agent	Contact Address / Nos.	Contact Person	Products
Maccaferri Asia	Wisma Bonauli 4/F JI TB Simatupany Kav 15 12430 Jakata Indonesia Tel: (62 21) 750 6555 Fax: (62 21) 750 6553	Mr Michael Graham Marketing Manager	Gabions Macmat and Macmat-R Paragrid Paralink Reno Mattresses Terram Geotextiles- Drainage Composites Terram-Grid Green Terramesh Terramesh System
Paul A Engineers	Room 1702 Honest Motors Building 9-11 Leighton Road Causeway Bay Hong Kong Tel: 2887 1556 Fax: 2508 1688	Marketing Executive	Netlon Drain Mat Nelton Drain Pipe Soil Saver Eroison Control Jute Mat
Pegasus Greenland Company	5B Wah Hing Commercial Centre 383 Shanghai Street Kowloon Tel: 2191 4308 Fax: 2191 4012	D N Kua Manager	"ON" Method
Q&Q Exports International	3/117 Kumaresapuram Trichy 620 013 Tami Nadu India Fax: +91 431 554295 E-mail: gg@md3.vsnl.net.in	Mr S Williams	Coir Geotextiles
Reinforced Earth Pacific Ltd	Room 3009 New Trend Centre 704 Prince Edward Road East Kowloon Tel: 2782 3163 Fax: 2332 5521 E-mail: repac@vol.net Web: http://www.GroupeTAI.com Web: http://www.reco.aust.com	Marketing Executive	Reinforced Earth
Sonotec Far East Ltd	2/F 818 Fanling Nam Wa Fanling Tel: 2670 4014 Fax: 2670 4949	Jonathan Ford	Grasscrete

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf)

Table E1 - Contact List of Suppliers/Agents and Products (Sheet 4 of 4)

Supplier / Agent	Contact Address / Nos.	Contact Person	Products
Spray Engineering Co	G/F Fook Wo Building 20 Tai Wo Street Wanchai Hong Kong Tel: 2575 7871 or 2575 6125 Fax: 2838 2615 E-mail: j5757871@netvigator.com	Mr John K K So	Enkadrain Enkamat 7010 Enkamat 7018 NEC Coir NEC Jute Rock-Grass System Fortrac
Terram Limited	Mamhilad Park Pontypool Gwent NP4 0YR UK Tel: 44 (0) 1495 757722 Fax: 44 (0) 1495 762383	Mr Simon Evans	Terram Drainage Composite Terram Needlepunch Nonwoven Geotextiles Terram Nonwoven Geotextiles Terram Protect and Terram Drain Terram Woven Geotextile
Toyo Greenland Co Ltd	No. 58C South Section Wah Shan Village Sheung Shui NT Tel: 2639 9312 Fax: 2377 2150	Daniel Ho (Managing Director)	Kangaroo Net (II) Toyo-Mulching System
Yeargold Engineering Ltd	Room 12 9/F Kenning Industrial Building 19 Wang Hoi Road Kowloon Bay Kowloon Tel: 2709 0616 Fax: 2709 2715		Terram Woven Geotextile Terram Nonwoven Geotextiles Terram Needlepunch Nonwoven Geotextiles Terram Protect and Terram Drain Terram Drainage Composite

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf)

Table E2 - Summary of Proprietary Products and Techniques which Have Previously Been Used in Hong Kong (Sheet 1 of 8)

Product Name	Atlantis Drainage Cells	Coir Erosion Control Blankets	Doran I.C.B. Crib Wall	Enkadrain
Description	Various drainage cell systems with differnet cell size	Erosion control blanket made of coir mattress fibres	A gravity retaining wall system	A drainage membrane of sandwich material
Applications	Primarily for on-site storm water management, which includes strip filter pipes, retaining walls drainage, civil work projects on drainage and water management	Soil erosion protection and slope revegetation	Retaining wall	Horizontal or vertical drainage of soft soil to accelerate consolidation and drain excess water in planter, for soil behind retaining wall and slope work
Supplier	Atlantis Corporation Pty Ltd	Bonterra Lanka	Doran (H.K.) Ltd.	Akzo Nobel Geosynthetics
Agent	L. F. Sam (H.K.) Ltd.	Apex (Asia-Pacific) Pty Ltd.	Nil	Spray Engineering Corp.
Source	Australia & Malaysia	Sri Lanka	Material :H.K. Technique: New Zealand	Germany
Capital Cost ($HKD/m^2)	Cell - $100 -$140 depends on thickness of cell Filter fabric - $3500 per roll of 300 m^2 each roll	Various depending on weight of blanket	$580/$m^2$ (single cell) $900/$m^2$ (doulble cell) $1,200/$m^2$ (triple cell) (Note: materials only)	$40 to $90 depends on models
Recurrent Cost ($HKD/$m^2$)	Nil	Not supplied	Not supplied	Nil
Availability	No stock in HK	ex-stock	Available in H.K.	Limited stock in H.K.
Ordering Time	4 weeks	2 - 3 weeks (out of stock items)	1 month written notice prior to the delivery of first batch	5 weeks
Minimum Order	Nil	No minimum	Nil	35-500 m^2
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	Over 50 years	Temporary biodegradable product	Over 20 years	25 years
Testing Authority	Insearch Limited, Sydney, Australia	Not supplied	MWD Testing Laboratory	1. Karlsruhe University of Technology (German) 2. EMPA (Switzerland) 3. CEMEREX and CEMAGREF (France) 4. Tested and approved by Germen & French railways, DBB and SNCF
Limitations on Use	Not supplied	Not supplied	1. Minimum width: 1.2 m 2. Maximum height: 5 m (for single-cell), 5-7m (for twin-cell) 3. Maximum radius: 25 m (for curved walls)	Not supplied
Use in Hong Kong	1. 51 Deep Water Bay Road 2. 3 Repluse Bay Road 3.Parkside Villa in Hong Kong (etc.)	Has previously been used in Hong Kong	1. North Lantau Expressway - Tung Chung Section 2. TM 80/93 Combined Pedestrian/ Cycle Bridge in Area 35, Tuen Mun 3. HY/93/14 Improvement to Tuen Mun Road (etc.)	1. GE/95/01, Slope No. 11SE-A/FR12, Tin Hau Temple Road 2. GE/98/01, Slope No. 11NW-D/FR222 & C5 3. GE/98/10, Slope No. 11NW-A/F28, Ching Cheung Rd
Use Overseas	1. Holland - Eindhoven - Renovation of sewerage in city street situation 2. Vietnam - Ho Chi Minh City - DBS Serviced Apartment 3. Singapore - Raffles Hotel (etc.)	Many projects in Europe, USA and Asia	Not supplied	1. 4 Season Park, Singapore 2. MTR 405, Singapore 3. Woodbridge Hospital, Singapore

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E2 - Summary of Proprietary Products and Techniques which Have Previously Been Used in Hong Kong (Sheet 2 of 8)

Product Name	Enkamat 7010	Enkamat 7018	Forta Concrete	Gabions
Description	3-dimensional random polyamide matting	3-dimensional random polyamide matting	Fibre reinforced sprayed concrete	Wire mesh boxes with rock infill
Applications	Soil erosion protection of embankments and slopes. Assists in developing vegetation on the surface	Soil erosion protection of embankments and slopes. Assists in developing vegetation on the surface	Heavy duty sprayed concrete cover applied to slopes, tunnels and walls	Retaining walls, channal lining, weirs, erosion control
Supplier	Akzo Nobel Geosynthetics	Akzo Nobel Geosynthetics	Forta Corporation	Maccaferri Gabions of Indonesia, PT
Agent	Spray Engineering Corp.	Spray Engineering Corp.	Bumatech	Constructional Systems Ltd.
Source	Germany	Germany	U.S.A	Manufactured in Indonesia & Malaysia
Capital Cost ($HKD/m^2)	$24-$36	$25-$38	$180/kg	Approximately $24 (mesh only)
Recurrent Cost ($HKD/m^2)	Nil	Nil	Nil	Nil if installed properly
Availability	Limited stock in H.K.	Limited stock in H.K.	Limited stock available in HK	Stock in HK, readily available in Indonesia & Malaysia
Ordering Time	6 weeks	6 weeks	6-8 weeks	less than 4 weeks
Minimum Order	150 m^2	120 m^2	50 bags	one 20' container
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	over 25 years	over 25 years	over 100 years	Up to 120 years for PVC coated units
Testing Authority	Nil	Nil	1. South Dakota School of Mines & Technology 2. Hardy BBT Ltd.	BBA certificate, various independent laboratories
Limitations on Use	Slope not greater than 80 - 90 degrees	Slope not greater than 80 - 90 degrees	An alternate system for non-structural secondary and /or temporary reinforcement	Suggests that product is not used in highly corrosive environments
Use in Hong Kong	1. Lam Tei Quarry, Tuen Mun 2. Slope Remedial Works for Tai Lam Chung Overhead Line Tower 3. Advances Slope Works 91-93 (etc.)	1. Slope Stabilisation Works at Fei Chui Road, Chaiwan 2. Landslip Preventive Measures 96/97 Contract No. GE/95/17 3. Slope Stabilisation Works to Hillside at Shum Wan Road, H.K. (etc.)	1. Wah Fu To New Tin Wan Cable tunnel - Shotcrete tunnel 2. Special School at Area 6, Yuen Long - Floor Slab (etc.)	Widely used in Hong Kong
Use Overseas	Not supplied	Not supplied	1. Atlanta's Olympic Stadium 2. Calgary Winter Olympics 3. St. Louis International Airport	Used in many countries worldwide

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E2 - Summary of Proprietary Products and Techniques which Have Previously Been Used in Hong Kong (Sheet 3 of 8)

Product Name	Grasscrete	Grassguard	Kangaroo Net (II)	Miradrain
Description	Cast in situ reinforced concrete layer with voids for planting (grass)	Pre-cast concrete paving units with voids for grass planting	Woven net comprising seeds, fertilizer and water holding agent	Composite filter and dimpled polymer membrane
Applications	Environmental armour layer to slopes, water courses and hard standings	Essentially used for vegetated hard standings, can also be used on sloping ground	Soil erosion protection applied to landslide area, slope with soil nail head, non-soil embankment and steep gradient slope	Drainage membrane used for slopes and retaining walls
Supplier	Grass Concrete International Ltd.	Marshalls Mono Ltd.	Toyo Greenland Co., Ltd.	TC MiraDRI
Agent	Sonotec Far East Ltd.	Fastman International Ltd.	Toyo Greenland Co., Ltd.	Bumatech
Source	Plastic void formers maufactured in UK	England	Not supplied	U.S.A.
Capital Cost ($HKD/m^2)	$200 - $300 dependent on type	1. Grassguard 130 (500x300x100 mm) - $309 2. Grassguard 160 (600x400x120 mm) - $381 3. Grassguard 180 (600x400x120 mm) - $468	$100 - $120	$148
Recurrent Cost ($HKD/m^2)	Nominal- grass cutting	Nil	Not supplied	Nil
Availability	Not supplied	Not available in HK normally	Not supplied	Limited stock available in HK
Ordering Time	2 weeks	5 weeks	Not supplied	6-8 weeks
Minimum Order	Nil	Nil	50 m^2	18.6 m^2/roll
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	40 years	Not supplied	Not supplied	over 200 years
Testing Authority	CIRIA	NAMAS accredited laboratories in UK	Tokyo Regional Forestry Department, Forestry Agency, Japan	Geosyntec, USA
Limitations on Use	Prolonged exposure of plastic formers to UV should be avoided	Less than 45 degrees	Not supplied	Not supplied
Use in Hong Kong	Used in Hong Kong since 1986	1. Grassguard 130 - Air traffic control complex & tower, Chek Lap Kok 2. Grassguard 180 - Lantau fixed crossing - Contract No.HY/94/04 3. Grassguard 180 - Cathy Pacific Flight Training Center	Smithfield Road (HY/94/20)), No. 3 Repulse Bay Road	1. Tseung Kwan O Landfill (CV/91/06) - Slope Drainage 2. Laguna Verde P.2 & P.3 - Hok Un Redevelopment - Slope Drainage, Retaining wall
Use Overseas	Singapore, Europe, USA, Russia, etc	1. Bothwell Castle, Strathclyde 2. Embankment Stabilization, Evesham 3. Sherwood Visitor Centre, Nottinghamshire 4. Reservoir Embankment, Leeds	Not supplied	1. Brooks Mental Hospital, Charleston, SC 2. Century Plaza, San Antonio, TX 3. Castle Pine Golf Course, Castle Pines, CO

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E2 - Summary of Proprietary Products and Techniques which Have Previously Been Used in Hong Kong (Sheet 4 of 8)

Product Name	Mirafi Geotextiles	Miramat	NEC Coir	NEC Jute
Description	Range of synthetic geotextiles	Green 3-dimensional polymer blanket	Biodegradable coir mesh	Biodegradable jute mesh
Applications	Geotextiles can be used for soil erosion control, separation filters and soil reinforcement	Soil erosion control on slopes	Soil erosion protection of slopes	Soil erosion protection of slopes
Supplier	TC MiraDRI	TC MiraDRI	Not supplied	Not supplied
Agent	Bumatech	Bumatech	Spray Engineering Corp.	Spray Engineering Corp.
Source	U.S.A.	U.S.A.	India	India
Capital Cost ($HKD/m^2)	$21.5 - $40	$73	$10	$8
Recurrent Cost ($HKD/m^2)	Nil	Nil	Nil	Nil
Availability	Limited stock available in HK	Limited stock available in HK	Limited stock in H.K.	Limited stock in H.K.
Ordering Time	6-8 weeks	6-8 weeks	4 weeks	4 weeks
Minimum Order	1 roll (418-585 m^2/roll)	1 roll (111m^2/roll)	2 m x 50 m	1.219 m x 68.58 m
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	over 200 years	over 200 years	10 years	6-12 months
Testing Authority	Geosyntec, USA	Geosyntec, USA	Not supplied	Nil
Limitations on Use	Not supplied	For slope erosion control only	Slope not greater than 90 degrees	Slope not greater than 90 degrees
Use in Hong Kong	1. Ma Hang Village (66/1993); North Lantau Expressway - Tung Chung 2. Chep Lak Kok (Contract 452); Central Reclamation Phase 2	1. Slope No. 7SW-B/C 123 Ville De Cascade, Shatin (GE/96/03) 2. Slope Abuttting the access road to Sha Ling Borrow Area - Landslip Preventive Works (GE/96/03) (etc.)	Drainage Maintenance & Construction in Mainland North Districts(1996-1998), Kowloon Hang Tai Po	Drainage Maintenance & Construction in Mainland North Districts(1996-1998), Kowloon Hang Tai Po
Use Overseas	1. US 90 Highway, Louisiana, USA 2. Wright Patterson Landfill Voids Bridgig, Ohio, USA 3. A15 Motorway, Paris	1. River Bank Projection - Batangas, Philippines 2. Schalkmuble Landfill Project, Netherlands	Not supplied	Not supplied

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E2 - Summary of Proprietary Products and Techniques which Have Previously Been Used in Hong Kong (Sheet 5 of 8)

Product Name	Netlon Drain Mat	Netlon Drain Pipe	"ON" Method	Permacrib
Description	3-dimensional non-woven matting	High density polyethylene mesh pipe with apertures	Sprayed seeds, fertilizer, resin and soil mix together with Portland cement	Gravity retaining wall system constructed from timber with stone infill
Applications	Sub-surface drainage from the back of retaining walls, and under fill slopes	Sub-surface drainage from the back of retaining walls, and under fill slopes	Vegetation of steep rock slope, concrete and/or mortar	Ground retention in both cut and fill situations
Supplier	1. Mitsui Petrochemical Industrial Products, Ltd. 2. Hogo Sangyo Co Ltd.	1. Mitsui Petrochemical Industrial Products, Ltd. 2. Hogo Sangyo Co Ltd.	Pegasus Greenland Company	Bonterra Weiland GmbH
Agent	Paul A. Engineers	Paul A. Engineers	Pegasus Greenland Company	Apex (Asia-Pacific) Pty Ltd.
Source	Japan	Japan	Not supplied	New Zealand
Capital Cost ($HKD/m^2)	$600/piece	$28.5/m to $125/m depends on diameter of pipe	$750 - $850	Varies, depending on soil, loading, conditions and height of wall
Recurrent Cost ($HKD/m^2)	Nil	Nil	Not supplied	Not supplied
Availability	model:30-200FC are available	40, 50, 65, 100, 145, 150 and 200mm dia pipes are available	Not supplied	ex-stock
Ordering Time	4 - 5 weeks	45 days after receipt of confirmation order	Not supplied	2 - 4 weeks (out of stock items)
Minimum Order	Nil	Nil	Not supplied	No minimum
Technical Specification (Y/N)	N	Y	Not supplied	Y
Longevity	At least 20 years	At least 20 years	> 12 months	125 years
Testing Authority	1. Department of Civil & Structural Engineering, Hong Kong Polytechnic 2. Construction Mechanization Research Institute of the Japan	Hong Kong Public Works Central Laboratories	Not supplied	Not supplied
Limitations on Use	Nil	Nil	Not supplied	Not supplied
Use in Hong Kong	1. C/No: GE/94/02 Upgrading of Retaining walls, Cut Slopes Fill Slopes & Rock Slopes in H.K. Island, Kowloon & N.T. 2. Slope Protection at Methodist Church, North Point (etc.)	1. C/No: EP/SP/10/91 TKO SENT Landfill 2. Route 3 Project 3. Tseung Kwan O Landfill Restoration (etc.)	5/GCO/83 (E.D.D.), 183/85 (H.A.), 01/HY/87 (HyD)	Has previously been used in Hong Kong
Use Overseas	1. Chubu Electric Power Company - drain at the hidden wall of the dam 2. Kochi Prefecture Public Works- drain at the hidden side of the retaining wall (etc.)	Not supplied	Not supplied	Bexley Heath (UK), Fairfax County (Washington, USA), Sopron (Hungary)

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E2 - Summary of Proprietary Products and Techniques which Have Previously Been Used in Hong Kong (Sheet 6 of 8)

Product Name	Recyfix Turf-Honeycomb	Reinforced Earth	Reno Mattresses	Rock-Grass System
Description	PE-HD plastic honeycombed cells that can be turfed	A technique which comprises a concrete facing panel, reinforcing strips and selected backfill	A heavily galvanised steel wire mesh box-shape baskets of various sizes filled with clean-hard stone	A system made of a coconut fibre netting covered by Enkamat and a high tensile, low creep polyester net
Applications	Soil erosion protection of river banks and slopes. Also used for grass areas that are occasionally used for vehicle access	Retaining walls	Channel Lining, erosion control, river training	Establishment of vegetation on eroded, rocky slopes
Supplier	Hauraton GmbH & Co KG	Reinforced Earth Pacific Limited	Maccaferri Gabions of Indonesia, PT	Spray Engineering Corp.
Agent	Fastman International Ltd.	Reinforced Earth Pacific Limited	Constructional Systems Ltd.	Spray Engineering Corp.
Source	Germany	Panel: Dongguang Reinforcing galvanized strip: South Africa	Manufactured in Indonesia & Malaysia	Technique: Hong Kong Material: Enkamat from Germany
Capital Cost ($HKD/m^2)	$220	Not supplied	Approximately $27 (mesh only)	$350-$400
Recurrent Cost ($HKD/m^2)	Nil	Not supplied	Nil if installed properly	Nil
Availability	Normally free stock ex-factory	No stock in H.K.	Stock in HK, Readily available in Indonesia & Malaysia	Limited stock in H.K.
Ordering Time	4 weeks for seafreight; 1 week for airfreight	1 week for panel 6 weeks for reinforced galvanized strip	less than 4 weeks	6 weeks
Minimum Order	1 pallet, 282 pieces	Nil	one 20' container	100 m^2
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	A man's life	120 years	Up to 120 years for PVC coated units	over 20 years
Testing Authority	LGA - Materialprufungsamt Abteilung Massivbau und Konstruktionen	1. TUV-Rheinland South Africa Group 2. Rand York Castings CC 3. Transvaal Galvanizers (etc.)	BBA certificate, various independent laboratories	Nil
Limitations on Use	Fine soil required for the grass to grow	Economically feasible when surface area of retaining wall at least 200 - 300m^2	Suggests that product is not used in highly corrosive environments	Slope not greater than 90 degrees
Use in Hong Kong	Tsui Ping Housing Estate	1. Route 3 Country Park Section, Yuen Long Approach Bridge 7, Abutment Wall & Retaining Wall 2. Ngau Tam Mei Treatment Works Wall No. 5 3. French International School (etc.)	Widely used in Hong Kong	1.1986 Jordan Valley Redevelopment 2.1994 Keng Shan Road Lantau Island 3.1997 Kowloon Hang River Training 4.1997 The Chinese University of Hong Kong (etc.)
Use Overseas	Kwun Ming Hotel	1. Stabilisation of Cairnmuir Landslide, Clyde Dam, New Zealand 2. The costal road embankment around Lake Hakuryuu (White Dragon) in the Hiroshima Perfecture 3. Retaining wall at Mount Steele on Leighton's Eastern Distributor in Sydney	Used in many countries worldwide	1. Schalksmule, Germany 2. Grignano Trieste, Italy 3. Fuji National Park, Japan

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E2 - Summary of Proprietary Products and Techniques which Have Previously Been Used in Hong Kong (Sheet 7 of 8)

Product Name	Soil Saver Erosion Control Jute Mat	Terra Drain	Terram Drainage Composites (1A1, B1, 1B1 & 1BZ)	Terram Drainage Composites (DC-1C &DC-1D)
Description	Heavy woven jute mesh	Pre-fabricated drainage system	Black polymer extruded core covered with nonwoven geotextile and/or low-density polyethylene film	High flow, high strength, low creep drainage composites. Cuspated polystyrene core covered with nonwoven geotextile
Applications	Soil erosion control on slopes	Subsurface drainage	Separation, filtration, protection and drainage, accelerated consolidation of fine soils	Separation, filtration, protection and drainage, protection of waterproof and drainage systems
Supplier	The Champdany Industries Ltd.	Webtec Inc.	Yeargold Engineering Co. Ltd.	Yeargold Engineering Co. Ltd.
Agent	Paul A. Engineers	Apex (Asia-Pacific) Pty Ltd.	Yeargold Engineering Co. Ltd.	Yeargold Engineering Co. Ltd.
Source	India	USA	Terram Ltd.	Terram Ltd.
Capital Cost ($HKD/m^2)	$1,338.88/roll	Varies, depends on types	40	65
Recurrent Cost ($HKD/m^2)	Nil	Not supplied	Nil	Nil
Availability	stock in H.K.	ex-stock	Unlimited	Unlimited
Ordering Time	30 - 45 days	2 - 3 weeks (out of stock)	Immediate, available from stock	Immediate, available from stock
Minimum Order	Nil	No minimum	50 m^2	40 m^2
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	2 years	Expected long-term lifespan	N/A (because project specific)	N/A (because project specific)
Testing Authority	Not supplied	Not supplied	Regular in-house testing, external independent testing	Regular in-house testing, external independent testing
Limitations on Use	Nil	Not supplied	Polypropylene may be damaged by UV light and direct contact with some chemicals	Polypropylene may be damaged by UV light and direct contact with some chemicals
Use in Hong Kong	1. C/No.: GE/90/05 slope Stabilisation Works at Ngau Chi Wan Borrow Area 2. Landslide Preventive Measure 1987/88 Program GCO-Package 1, Slope No. 6SW-D/C9 at Siu Lam, Tuen Mun (etc.)	Has previously been used in Hong Kong	1. Lantau Fixing (Tsing Ma Bridge) 2. Tin Wan Station, HK Electric 3. American Embassy	1. Ho Man Tin Reservoir 2. So Kwun Fat Residential Project
Use Overseas	Not supplied	Used extensively in USA market	1. Markstein Tunnel, Germany 2. M26 Motorway, UK 3. Hewlett Packard Building, UK	Hewletts Reservoir, Cheltenham, UK

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E2 - Summary of Proprietary Products and Techniques which Have Previously Been Used in Hong Kong (Sheet 8 of 8)

Product Name	Terram Nonwoven Geotextiles	Toyo-Mulching System
Description	Thermally bonded, nonwoven geotextiles	Seed and soil mix sprayed onto non-soil surface of bedrock, sprayed concrete, mortar or chunam
Applications	Ground stabilisation, separation and filtration on roads, railways and drainage etc.	Can be applied on any non-soil surface of bedrock, spray concrete, mortar, no fines concrete or chunam.
Supplier	Yeargold Engineering Co. Ltd.	Not supplied
Agent	Yeargold Engineering Co. Ltd.	Toyo Greenland Co., Ltd.
Source	Terram Ltd.	Not supplied
Capital Cost ($HKD/m^2)	Terram 1000 & 1000-N: $8	$400-$450 for general Toyo-Mulching, $450-$500 for strip Toyo-Mulching, $800-$900 for Creat Toyo-Mulching
Recurrent Cost ($HKD/m^2)	Nil	Not supplied
Availability	Unlimited	Not supplied
Ordering Time	Immediate, available from stock	Not supplied
Minimum Order	450 m^2	$150,000 per contract sum
Technical Specification (Y/N)	Y	Y
Longevity	up to 40 yrs (possibly 100 yrs)	Not supplied
Testing Authority	Regular in-house texting, independent testing by BTTG	Tokyo Regional Forestry Department, Forestry Agency, Japan
Limitations on Use	Polypropylene may be damaged by direct contact with some chemicals	Not supplied
Use in Hong Kong	1. North Point Government Building 2. Hong Kong Station, MTRC 3. Kowloon Station, MTRC 4. CLK Airport, Hong Kong (etc)	Smithfield Road (HyD), Chinese University
Use Overseas	1. Croydon Tramlink, UK 2. Barrie Burn Erosion Control, Scotland 3. M1 Motorway, UK (etc)	Creat Toyo-Mulching had applied in Japan

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E3 - Summary of Proprietary Products and Techniques which Have Not Been Used in Hong Kong (Sheet 1 of 8)

Product Name	Biobarrier	Coconut Meshes	Coir Geotextiles	CoirMesh
Description	A root control system made of geotextile fabric with permanantly attached nodules containing trifluralin which prevents root tip cell division	Biodegradable mesh made of fibre of coconut	A woven geotextile made of 100 % organic coconut fibre	Biodegradable coir mesh
Applications	Protects building foundations, pavement, underground utilities and landscaped beds from root and weed. Biobarrier I - mainly vertical use for root control, Biobarrier II - mainly horizontal use for weed control	Soil erosion protection for slopes, uplands, coasts and waterways	Soil erosion protection of slopes	Soil erosion protecton for slopes, uplands, coasts and waterways
Supplier	BBA Nonwovens - Reemay, Inc.	Hy-Tex (UK) Ltd.	Q & Q Exports International	Hy-Tex (UK) Ltd.
Agent	Nil	Not supplied	No agent in HK	Not supplied
Source	BBA Nonwovens - Reemay, Inc.	India	Manufactured at Allapuzha (Kerala state in India)	India
Capital Cost ($HKD/$m^2$)	NA (because site specific)	$21	$5-$14 (installation & freight charges excluded)	$18
Recurrent Cost ($HKD/$m^2$)	Nil	Not supplied	Nil	Not supplied
Availability	Available in USA	Not supplied	No stock in HK	Not supplied
Ordering Time	4 - 6 weeks	Not supplied	3 - 4 weeks	Not supplied
Minimum Order	Nil	100 m^2	5 000 m^2	100 m^2
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	Biobarrier I - 15 yrs warranty, Biobarrier II - 10 yrs warranty	4-10 years	< 5 years	4-10 years
Testing Authority	Not supplied	Silsoe College (Cranfield University)	COIR BOARD	Silsoe College (Cranfield University)
Limitations on Use	Must be properly installed and left exposed	Only intended for temporary surface protection and vegetation promotion	After 5 years, the product slowly degrades leaving only humus	Only intended for temporary surface protection and vegetation promotion
Use Overseas	Many installations in Japan, South Africa and Puerto Rico	Used throughout the world	Librec City of Czech Republic	Used throughout the world

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E3 - Summary of Proprietary Products and Techniques which Have Not Been Used in Hong Kong (Sheet 2 of 8)

Product Name	Erosion Control Blankets	Fortrac	Green Terramesh	Hastec Erosion Control System - erosion control fibre
Description	Light to medium weight blankets made of decomposable coir or straw within a thin jute or polymer net	Geogrid made of high modulus polyester covered by PVC coating	Double twist hexagonal mesh gabion box with mesh panel	Coir fibre fabrics
Applications	Soil erosion control for slopes	Reinforced soil typically for retaining walls and fill slopes	Soil reinforced retaining walls	Soil erosion control of slopes
Supplier	Greenfields	Akzo Nobel Geosynthetics	Maccaferri Gabions of Indonesia, PT	Hastec
Agent	Jacobson van den Berg (Far East) Ltd.	Spray Engineering Corp.	No agent in HK	Jacobson van den Berg (Far East) Ltd.
Source	Germany	Germany	Manufactured in Indonesia & Malaysia	Germany
Capital Cost ($HKD/$m^2$)	$6.50	$17- $120 depends on type	Approximately $27	KGW 700 LC - $14.5 KWG 900 LC - $17
Recurrent Cost ($HKD/$m^2$)	Nil	Nil	Nil if installed properly	Nil
Availability	No stock in H.K.	Limited stock in H.K.	Available in Indonesia & Malaysia	No stock in H.K.
Ordering Time	30 days	5 weeks	less than 4 weeks	30 days
Minimum Order	5,000-12,000 m^2 (1 full container)	500 m^2	one 20' container	5 000-12 000 m^2 (1 full container)
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	Decomposition time is 2 years for blankets of 450 g/m^2	100 years	Up to 120 years for PVC coated units	At least 3 years
Testing Authority	Institute for Geotechnik und Grundban of the University GH Siegen	1. Fachhochoschule Munster LGA Landesgewerbeanstalt Bayern 2. TBU Institute fur textile Bauund Umwelttechnik GmbH	BBA certificate, various independent laboratories	Institute fur Geotechnik und Grundbau of the University GH Siegen
Limitations on Use	For slopes up to 90 degree, combination with hydroseeding is highly recommended	Slopes less than 75 degrees only	Suggests that product is not used in highly corrosive environments	For slopes up to 90 degree, combination with hydroseeding is highly recommended
Use Overseas	Not supplied	Not supplied	Used in many countries worldwide	Not supplied

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E3 - Summary of Proprietary Products and Techniques which Have Not Been Used in Hong Kong (Sheet 3 of 8)

Product Name	Hydroseed with Seanure Soilbuilder	Macmat and Macmat-R	Manta Ray	Miragrid Geogrid
Description	Soil builder incorporated into seeding mulches to enable direct seeding onto sub-soil	3-dimensional polymer geomat (Macmat) reinforced within a double twisted hexagonal mesh (Macmat-R)	Mini anchorage system comprising an anchor and wire attachment	High-strength flexible polyester geogrid
Applications	Establish vegetation on roads and railways, in quarries, costal sites, landfill sites etc.	Permanent erosion control mat	Anchorage for structural facings on soil slope, retaining wall	Soil reinforcement for fill slopes
Supplier	Comtec Civil Engineering Limited	Maccaferri Gabions of Indonesia, PT	Foresight Products, LLC	TC MiraDRI
Agent	No agent in HK	No agent in HK	Bumatech	Bumatech
Source	UK	Manufactured in Italy	USA	U.S.A
Capital Cost ($HKD/m^2)	$6 - $8	Approximately $39 for Macmat, $62 for Macmat-R	$300-$350/LM	$95-$160
Recurrent Cost ($HKD/m^2)	$6/year	Nil if installed properly	Nil	Nil
Availability	Available in UK	Available in Italy	Limited stock available in HK	Limited stock available in HK
Ordering Time	4 weeks	8 weeks	6-8 weeks from US to HK	6-8 weeks
Minimum Order	160 000 US Dollars	One x 40' container	50 sets	1 roll
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	120 design life	Usual geosynthetic longevity	Same as hot-dip galvanised steel product	over 100 years
Testing Authority	Not supplied	Internal Testing	Not supplied	Geosytec, USA
Limitations on Use	Aftercare (watering) is important to establish growth.	Suggests that product is not used in highly corrosive environments	Cannot drill through hard rock	Reinforcement application
Use Overseas	Used in UK and Africa	Widely used in Italy	1. Mnata Ray Hybrid Retaining Wall, Minnesota, USA 2. Tahoe Keys Resort Sheet Pile Bulkhead Restoration, Californis, USA	1. US Army COE Mississippi River Slope Repair 2. Jefferson County Landslide Repair 3. New Jersey DOT UD Route 1 at Princeton Market Fair

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E3 - Summary of Proprietary Products and Techniques which Have Not Been Used in Hong Kong (Sheet 4 of 8)

Product Name	Natural fibre geotextile	Paragrid	Paralink	Revetlok
Description	Coir and jute biodegradable geotextile	Grid made of synthetic materials	Grid made of synthetic materials	A modular gravity wall system comprising pre-cast concrete blocks
Applications	Soil erosion control on slopes, river and channel embankments, shore line stabilisation, agriculture and horticulture	Retaining walls, slope reinforcement	Embankment support, pile support	Gravity retaining wall
Supplier	Aspinwall Geotech Limited	Maccaferri Asia	Maccaferri Asia	Marshalls Mono Ltd.
Agent	No agent in HK	No agent in HK	No agent in HK	Fastman International Ltd.
Source	Manufactured in India	Manufactured in UK	Manufactured in UK	England
Capital Cost ($HKD/m^2)	Not supplied	$39 - $78	$39 - $273	$2000 depends on scope & time for technical input
Recurrent Cost ($HKD/m^2)	Not supplied	Nil if installed properly	Nil if installed properly	Nil
Availability	Available in India	made to order	made to order	Normally no stock available in HK
Ordering Time	Minimum 25 days	6 - 10 weeks	6 - 10 weeks	7-10 weeks
Minimum Order	One 20' container	One 20' container	One 20' container	Nil
Technical Specification (Y/N)	Y	Y	Y	N
Longevity	About 2 years	Up to 120 years for PVC coated units	Up to 120 years for PVC coated units	Not supplied
Testing Authority	Not supplied	BBA certificates, various independent laboratories	BBA certificates, various independent laboratories	NAMAS accredited laboratories in UK
Limitations on Use	Not supplied	Recommended not to be used in pH>11 material	Recommended not to be used in pH>11 material	1. Maximum height 2 to 3 m (for single skin Revetlok wall) 2. Greater heights require double or mutiple skins 3. Wall can be built up to 90 degrees
Use Overseas	Used in Europe, UK, Scandinavia, USA, Korea, Japan, etc	Widely used in many countries	Widely used in many countries	1. Newcastle Airport, Newcastle 2. Running Track, Grangemouth 3. Sony Headquarters, Byfleet, Surrey 4. Ben Nevis Distillery, Fort William, Scotland

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E3 - Summary of Proprietary Products and Techniques which Have Not Been Used in Hong Kong (Sheet 5 of 8)

Product Name	Soil Panel	Soil Saver Jute Mesh	Tensar Wall Blocks	Terra Cell
Description	Soil nail with galvanised steel panel attached to slope face filled with soil for planting	Biodegradable jute mesh	Reinforced soil system using concrete blocks, capable of receiving natural stone facing	A cellular confinement system
Applications	Soil reinforcement of steep slopes	Soil erosion protection during seed germination applied to general slopes	Construction of retaining walls and bridge abutments	Slope erosion control
Supplier	Phi Group NZ Ltd.	Hy-Tex (UK) Ltd.	Comtec Civil Engineering Limited	Webtec Inc.
Agent	Apex (Asia-Pacific) Pty Ltd.	Not supplied	No agent in HK	Apex (Asia-Pacific) Pty Ltd.
Source	New Zealand	India	UK	USA
Capital Cost ($HKD/$m^2$)	Varies, depending on size and length of soil nail and access	$4.50	$2,030 - $2,270	Varies, depending on size and depth of cell specified
Recurrent Cost ($HKD/$m^2$)	Not supplied	N/A	Nil	Not supplied
Availability	ex-stock	Not supplied	available in UK	ex-stock
Ordering Time	2 -3 weeks (out of stock items)	Not supplied	4 weeks	4 - 5 weeks (out of stock items)
Minimum Order	No minimum	84 m^2	160 000 US Dollars	No minimum
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	No data available	2-5 years	120 design life	Expected long-term lifespan
Testing Authority	Not supplied	Silsoe College (Cranfield University)	British Board of Agrement, Institute for Bautechnik	Not supplied
Limitations on Use	Not supplied	Only intended for temporary surface protection and vegetation promotion.	1. Walls up to 5 m high 2. Granular backfill required	Not supplied
Use Overseas	Used extensively in UK on M1, M4 and M5 road widening	Used throughout the world	Used in UK only	1. Pinellas Park (Florida, USA) 2. City of Charlotte (North Carolina, USA) 3. Hellertown (Pennsylvania)

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E3 - Summary of Proprietary Products and Techniques which Have Not Been Used in Hong Kong (Sheet 6 of 8)

Product Name	Terra Grid	Terram-Grid	Terram Needlepunched Nonwoven Geotextiles	Terram Protect and Terram Drain
Description	Polyester geogrid	Non-woven thermally bonded geotextile of high strength composite material	100% polyester nonwoven geotextiles	Drainage composite. Double dimple HDPE cuspated sheet glued with terram 700 geotextile
Applications	Soil reinforcement and embankment stabilisation	Soil reinforcing for fill slopes and block wall systems	Ground stabilisation, separation, high filtration and protection	Separation, filtration, protection and drainage. Protection of waterproof systems and for vertical drainage to structure
Supplier	Webtec Inc.	Maccaferri Asia	Yeargold Engineering Co. Ltd.	Yeargold Engineering Co. Ltd.
Agent	Apex (Asia-Pacific) Pty Ltd.	No agent in Hong Kong	Yeargold Engineering Co. Ltd.	Yeargold Engineering Co. Ltd.
Source	USA	Manufactured in UK	Terram Ltd.	Terram Ltd.
Capital Cost ($HKD/$m^2$)	Varies, depending on specification required	$39 - $78	Terram B-15 - $9	50
Recurrent Cost ($HKD/$m^2$)	Not supplied	Nil if installed properly	Nil	Nil
Availability	ex-stock	Made to order	Unlimited	Unlimited
Ordering Time	4 - 5 weeks (out of stock items)	6 - 12 weeks	4 - 8 weeks	4 - 8 weeks
Minimum Order	No minimum	One 20' container	1170 m^2	20 m^2
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	Expected long-term lifespan	Up to 120 years for PVC coated units	NA (because project specific)	NA (because project specific)
Testing Authority	Not supplied	BBA certificate, various independent laboratories	Internal quality testing, independent testing by USP Sao Carlos University	Routine in-house testing, independent external testing
Limitations on Use	Not supplied	Recommended not to be used in pH>11 material	Polyester may absorb water and mechanical properties lost through hydrolysis	Polypropylene and polyethylene may be damaged from direct contact with UV light and some chemicals
Use Overseas	Used extensively in USA and European markets	Widely used in many countries	Not supplied	Not supplied

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E3 - Summary of Proprietary Products and Techniques which Have Not Been Used in Hong Kong (Sheet 7 of 8)

Product Name	Terram Woven Geotextile	Terra-mesh System	Textomur Green	Textomur for Nailing
Description	Woven polypropylene geotextile, filters and meshes	Double-twist hexagonal wire mesh with stone infill in the face and compacted soil behind	Patented reinforced soil system utilising sacrificial steel mesh facing with planted or grassed final finish to slope up to 75° and 50 m high	As Textomur Green but modified to attach to soil nail heads giving a 1m thick facing which can be grassed, planted or finished in stone work
Applications	Ground stabilisation, separation and filtration in high flow applications	Soil reinforced retaining walls	Slope stabilisation and steep slope construction	Establish grass/vegetation to retaining features supporting facing (e.g. sprayed concrete)
Supplier	Yeargold Engineering Co. Ltd.	Maccaferri Gabions of Indonesia, PT	Comtec Civil Engineering Limited	Comtec Civil Engineering Limited
Agent	Yeargold Engineering Co. Ltd.	No agent in HK	No agent in HK	No agent in HK
Source	Terram Ltd.	Manufactured in Indonesia & Malaysia	Not supplied	Not supplied
Capital Cost ($HKD/$m^2$)	Terram 1000 - $35, Terram W/3-3 - $10,	Approximately $27 (mesh only)	$1,400 - $1,800	$1,560 - $2,030
Recurrent Cost ($HKD/$m^2$)	Nil	Nil if installed properly	$6/year	Nil
Availability	Unlimited	Available in Indonesia & Malaysia	Available in Taiwan	Available in Taiwan
Ordering Time	4 - 8 weeks	less than 4 weeks	6 weeks	6 weeks
Minimum Order	~ 500 m^2	one 20' container	160 000 US Dollars	160 000 US Dollars
Technical Specification (Y/N)	Y	Y	Y	Y
Longevity	NA (because highly site specific)	Up to 120 years for PVC coated units	120 design life	120 design life
Testing Authority	Routine in-house testing, independent external testing	BBA certificate, various independent laboratories	British Board of Agrement for Geogrid	British Board of Agrement for Geogrid
Limitations on Use	Polypropylene and polyethylene may be damaged from direct contact with some chemicals	Suggests that product is not used in highly corrosive environments	Aftercare is important to appearance, maximum preferred angle is 70°	Minimum required facing width is 1m
Use Overseas	1. A75 Creetown, Scotland 2. Barrie Burn, Scotland	Used in many countries worldwide	Used extensively in Taiwan, UK, Italy and Switzerland	Used extensively in Taiwan, UK, Italy and Switzerland

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

Table E3 - Summary of Proprietary Products and Techniques which Have Not Been Used in Hong Kong (Sheet 8 of 8)

Product Name	Textomur Stone	Timbacrib
Description	As Textomur Green but with permanent steel mesh and stone face finish. Face angle up to 90°	Gravity retaining wall system constructed from interlocking Radiata Pine timbers with stone infill
Applications	Slope stabilisation and steep slope construction etc.	Ground retention in both cut and fill situations
Supplier	Comtec Civil Engineering Limited	Comtec Civil Engineering Limited
Agent	No agent in HK	No agent in HK
Source	Not supplied	New Zealand
Capital Cost ($HKD/m^2)	$1,560 - $1,880	$1,880 - $2,340
Recurrent Cost ($HKD/m^2)	Nil	Nil
Availability	Available in Taiwan	Available in New Zealand
Ordering Time	6 weeks	3 weeks
Minimum Order	160 000 US Dollars	160 000 US Dollars
Technical Specification (Y/N)	Y	Y
Longevity	120 design life	50 yr material guarantee
Testing Authority	British Board of Agrement for Geogrid	No formal certificate
Limitations on Use	Stone depth can be restricted to 200 mm at face	Walls up to 7 m high
Use Overseas	Used extensively in Taiwan, UK, Italy and Switzerland	1. John Radcliffe Hospital, Oxford (UK) 2. Cornwall County Council (UK) 3. University of Sunderland (UK)

(Information contained in Appendix E is provided by manufacturers and agents. Interested parties should verify the information on their own behalf.)

APPENDIX F

LIST OF NATIVE PLANT AND SHRUB SPECIES

List of native tree and shrub species currently used but further information required relating to their establishment and growth characteristics.

Bauhinia blakeana
Bischofia trifoliata
Buxus microphylla
Castanopsis fissa
Celtis sinensis
Cerbera manghas
Choerospondias axillaris
Cinnamomum burmanni
Cinnamomum camphora
Cleistocalyx operculata
Ficus microcarpa
Ficus variegata
Ficus virens
Gardinia jasminoides
Gordonia axillaris
Hibiscus tiliaceus
Ligustrum sinense
Liquidambar formosana
Litsea glutinosa
Litsea monopetala
Macaranga tanarius
Mallotus paniculatus
Rhaphiolepis indica
Rhodomyrtus tomentosa
Sapium discolor
Sapium sebiferum
Schefflera ocotophylla
Schima superba
Sterculia lancelata

List of native tree and shrub species that are not commonly used, and should be trialled for suitability of use in slope works.

Ailanthus fordii
Aquilaria sinensis
Camellia crapnelliana
Camellia granthamiana
Camellia hongkongensis
Dianella ensifolia
Ficus superba
Glochidion hirsutum
Ilex rounda
Illicium dunnianum
Keteleeyia fortunei
Manglietia fordiana
Michelia maudiae
Myrica rubra
Pavetta hongkongensis
Rhododendron hongkongense
Rhododendron westlandii
Rhodoleia championi
Sloanea hongkongensis
Tutcheria spectabilis
Viburnum odoratissimum

APPENDIX G

GLOSSARY OF TERMS

Broadcast Seeding - traditional method of dispersing seed by hand.

Brushwood Bundles - technique for establishing plants by taking collections of long straight branches of small diameter cut from mature trees of certain species (e.g. Salix). The bundles are tied together in bundles and buried in soil. Branches can then root and grow into new trees if conditions are suitable.

Bush Layering - traditional technique for establishing trees (similar to brush wood bundles) with 1 m to 2.5 m straight branches of small diameter cut from mature trees of certain species (e.g. *Salix*). The cuttings are inserted into soil slopes (usually laid as part of the construction, with the roots buried by up to 600 mm, and the tip exposed. Branches are then able to root and grow into new trees if conditions are suitable.

Climax Species - plant species which is believed would naturally become dominant (i.e. if unaffected by human activity) within an area given sufficient time. Used to refer to those plants within a planting design that are intended to form the principle long term constituent of an area of vegetation.

Coir - fibre derived from coconut husks.

Composition of a Slope - how the individual elements of the slope come together to form the whole. Term principally relates to the proportion and arrangement of different components of a slope (faces, berms, verges, slope profiles and gradients) but may also refer to additional items such as drainage and access steps.

Epilithic Fern - a fern that grows on rock.

Exotic - not native to Hong Kong.

Grasscrete - proprietary product consisting of concrete layer with soil filled voids used for planting.

Grillage - generally a regular grid of beam laid or constructed onto the slope surface.

Groundcover - low plants and shrubs usually found amongst trees.

Jute - common name of, and fibre derived from, plants of the genus *Corchorus* (family *Tiliaceae*) similar to coir.

Live Pole - identical technique to bush layering but using larger branches set vertically, in pre-dug pits (can be driven into soft ground).

Native - found growing naturally in Hong Kong (i.e. not introduced).

Naturalised - introduced plant species that now grow in Hong Kong as if native (e.g. *Duranta repens*).

Ornamental Shrubs - shrubs commonly used for ornamental purposes, due to their leaf colour, shape, size, flowering characteristics. Many ornamental shrubs are exotic species and nearly all require some form of maintenance to keep their ornamental characteristic.

Pit planting - planting individual plant specimens in pre-dug holes in soil.

Understorey - term given to the shrub, field and herb layers of vegetation within a developed woodland structure.

Whip - horticultural nursery stock size (characteristic) for trees, as defined by Hong Kong Government (1992), also Seedling, Light Standard, Standard, heavy Standard, Extra Heavy Standard, Semi-Mature Tree.

Zonal Planting - planting within a predefined area.

Abbreviations:
sp. - a single species
spp. - a number of species within a genus
Latin names of plants are given in italics.