GEO Publication No. 1/2011

Technical Guidelines on Landscape Treatment for Slopes

Geotechnical Engineering Office
Civil Engineering and Development Department
The Government of the Hong Kong
Special Administrative Region

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Prepared by:

Geotechnical Engineering Office,
Civil Engineering and Development Department,
Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon,
Hong Kong.

Captions of Figures on the Front Cover:

Top Left	Vegetated Soil Cut Slope at South Lantau Road, near Mui Wo
Top Right	Retaining Wall at Victoria Road, Pokfulam
Bottom Left	Masonry Retaining Wall with Wall Trees at Conduit Road, Mid-levels
Bottom Right	Landscape Treatment Works for a Landslide at Po Lam Road, Tseung Kwan O

Foreword

This Publication presents guidance on good practice of landscape treatments for man-made slopes and engineering works on natural terrain in Hong Kong. It forms part of the continuing commitment by the Government of the Hong Kong Special Administrative Region to make slopes look as natural as possible, with a view to achieving the overall aim of creating a more visually acceptable and ecologically sustainable slope environment.

Since the issue of GEO Publication No. 1/2000 "Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls", which relates exclusively to man-made slopes, there has been continuous development in slope engineering and landscaping techniques, which provide more opportunities for planting. The GEO sees the need to update the Publication in order to promulgate the latest best practice and expand the scope to include landscape treatments for natural terrain mitigation works and landslide repairs.

This Publication was prepared by a Halcrow China Limited's team led by Mr Allan Watkins, in collaboration with Mr Matthew Pryor and Dr Billy Hau of the University of Hong Kong, together with input by landscape architects, ADI Limited. The preparation of the Publication was overseen by a Working Group comprising representatives from the GEO and relevant Government departments, Hong Kong Institution of Engineers, Hong Kong Institute of Landscape Architects, together with the University of Hong Kong and the Chinese University of Hong Kong. Members of the Working Group are shown on the next page.

Draft versions of the Publication were circulated to Government departments, local professional bodies, consulting engineers, landscape architects and ecologists. Many individuals and organisations provided very useful comments, which have been taken into account in the final version of the Publication. All contributions are gratefully acknowledged.

Practitioners are encouraged to provide comments to the Geotechnical Engineering Office on the contents of this Publication, so that improvements can be made in future editions.

R.K.S. Chan
Head, Geotechnical Engineering Office
September 2011

Working Group:

Agriculture, Fisheries and Conservation Department
Mr K.W. Cheung

Architectual Services Department
Mr S.P. Ng

Civil Engineering and Development Department (Geotechnical Engineering Office)
Mr Ken K.S. Ho (Chairman)
Mr Thomas H.H. Hui (Secretary)
Ms Florence W.P. Wong

Civil Engineering and Development Department (Landscape Unit/Headquarters)
Mr Eric W.K. Chan

Development Bureau
Ms Shirley Y.Y. Chan

Highways Department
Mr Jonathan C.W. Yung

Hong Kong Institute of Landscape Architects
Mr Simon H.W. Chan

Hong Kong Institution of Engineers (Geotechnical Division)
Mr Albert N.L. Ho

Housing Department
Mr Dennis W.L. Yip

The Chinese University of Hong Kong
Professor L.M. Chu

The University of Hong Kong
Professor C.Y. Jim

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1 Introduction

1.1 Purpose and Scope

The purpose of this Publication is to provide technical guidance on landscape treatments for man-made slopes and engineering works on natural terrain, with a view to enhancing slope appearance and making them ecologically acceptable and sustainable. The guidelines are based on best current practice in Hong Kong, together with experience from overseas that warrants consideration in Hong Kong's geological and environmental conditions.

The Publication is written for use by engineers and landscape architects, who are encouraged to work together on the design and implementation of landscape works for slopes. The guidelines cover new slope works, upgrading and improvement works to existing slopes, natural terrain landslide mitigation measures and landslide repairs. This Publication supersedes GEO Publication No. 1/2000 (GEO, 2000a).

1.2 Content of the Publication

Chapter 1 sets out the key objectives and approaches of landscape design in slope works. Chapter 2 presents the range of common landscape treatments and techniques. Chapter 3 discusses the processes in respect of selection, design and implementation of landscape treatments vis-à-vis engineering designs. Chapters 4 and 5 suggest potential applications of landscape treatments for various types of man-made slopes and natural terrain landslide mitigation measures respectively. Chapter 6 provides guidance on landscape works associated with landslide repairs. Chapters 7 and 8 recommend good practice in respect of supervision and maintenance of landscape works respectively.

Worked examples of the application of these guidelines are given in Appendix A.

1.3 General Guidance

The technical guidelines given in this Publication should only be applied where slope safety standards and requirements have been met. Designers should also bear in mind the need to consider the life-cycle cost and minimise future maintenance commitments.

These technical guidelines are for guidance and are not mandatory, nor should they be used in a prescriptive manner. They should not inhibit the development of new techniques, or approaches, to achieve the overall aim of creating a more visually acceptable and sustainable slope environment.

1.4 Landscape Objective

The overall objective of landscape treatment of slopes is to make them both visually acceptable and sustainable in the long term.

It is recognised that feasible engineering solutions may have significant impact on existing vegetation and the visual and ecological environment. Designers need to adopt an integrated approach to engineering and landscape works by collaborative working between engineers and landscape architects. Contributions of various parties at different stages of the slope works process are shown in Figure 3.1. Examples are given in Appendix A.

The key approaches that designers should consider when integrating landscape treatments with engineering works in order to achieve the landscape objective are:

(a) **Minimise Physical Impact** - addressing the effect of the proposed slope works on existing trees, vegetation, natural features and elements of value; achieving best fit to the surrounding landscape and topography; and reducing impact through improved visual treatment of slope elements and incorporation of planting.

(b) **Landscape Softworks** - planting of vegetation on the face or at the toe, crest or side edges of a slope, in order to create opportunities for ecological habitats to develop, to provide screening, for greening (naturalness), and to improve the environmental condition (e.g. create shade and shelter).

(c) **Landscape Hardworks** - the aesthetic treatment of hard slope covers, and exposed surfaces of the slope elements and furniture to make their appearance as visually acceptable as possible, to create visual interest and to make the slope compatible with its surroundings.

Aesthetics in general and views on the appearance of finished slopes can be quite subjective and are often a matter of personal preference. However, the examples given in Figure 1.1 offer some guidance based on previous successful landscape designs.

(a) Unity and coherence
- a clear design with simple combinations of materials or features that are visually understandable by viewers
- e.g. (left) planting at the toe and above the retaining wall successfully creates a unified appearance to the whole slope
- e.g. (right) consistent use of screen planting for channels and berms

(b) Proportion and scale
- size of particular components compared to others at a site should be appropriate
- e.g. suitable size and composition of the buttresses with ribbed finish and masonry facing blocks

(c) Pattern and texture
- create visual interest
- e.g. a variety of techniques used in a co-ordinated manner, resulting in a composition which has both pattern and texture

(d) Rhythm and complexity
- features overlaid or juxtaposed to create complexity of composition
- e.g. terraced structures to break up the overall wall height and provide planting opportunities

(e) Colour
- colours that respond to or complement those at the feature or its surroundings
- e.g. colours of random pattern masonry above matched the wall prior to works

(f) Albedo (reflectivity)
- aim to reduce reflectivity, especially if hard surfaces are used
- e.g. small block sizes, formed at differing heights, to break up potentially reflective surfaces

Figure 1.1 Examples of General Aesthetic Principles

2 Landscape Treatments

2.1 General

This Chapter contains descriptions of a range of common landscape treatments. The application of these treatments to different types of slopes is discussed in Chapter 4. Some treatments may be applicable to more than one type of slope and designers should take consideration of the surroundings in the design. Good practice for tree protection works and excavation in the vicinity of existing trees is provided in Section 7.2.

Photographic examples of selected landscape softworks and hardworks are given in Appendix B and Appendix C respectively.

2.2 Minimising Physical Impact

Often the greatest effect that an integrated engineering and landscape approach can bring to the design of slope works is simply minimising the impact on the existing landscape. Further enhancement can be made by reducing the impact through improved visual treatment and incorporation of planting in the works.

2.2.1 Limiting Impact

Without compromising slope safety, the extent and nature of slope works should be carefully considered to minimise the disturbance of existing vegetation. This can, to a degree, be achieved by minimising the footprint of the works on an existing landscape through:

(a) seeking steeper gradients to soil and rock slopes, thereby limiting land-take and loss of existing vegetation,

(b) use of vertical retaining structures instead of forming more extensive man-made slopes,

(c) maximising slope batter heights and minimising berm widths,

(d) use of techniques that do not involve re-grading/re-profiling (e.g. soil nailing),

(e) restricting the extent of temporary works, including access for construction, or

(f) housing facilities in tunnels or caverns, instead of cutting into existing hillsides.

While some of these measures may compromise opportunities for new planting, new vegetation should not be considered as a simple substitute for existing mature vegetation, as it may not have the same maturity and ecological diversity. Also, the change may result in loss of habitats for birds, insects and other animals. A balance needs to be achieved in slope works between retaining existing vegetation and creating opportunities for new planting. Consideration must be given to the ecological value of the existing vegetation and the time required for the new planting to have a similar ecological value. Where there are species of high ecological value, extra effort must be made to retain them with the input of an arborist, ecologist and/or other suitable specialist.

The baseline condition of existing trees should be established through tree surveys and, where necessary, tree risk assessments. Ecological surveys may also be required in Country Park and other sensitive site settings to ascertain that all rare or valuable vegetation, and ecological habitats, are recorded. Guidance on tree surveys and tree risk assessments is provided in ETWB TC(W) No. 3/2006 (ETWB, 2006), and the *Guidelines for Tree Risk Management and Assessment Arrangement on an Area Basis and on a Tree Basis* (DEVB, 2011a), respectively.

The removal or excess trimming of existing trees is strongly discouraged, and should only be considered where there are no practical engineering solutions. However, there may be circumstances whereby unstable or unhealthy trees may need to be removed. For Government slopes, full justification and prior written approval for tree removal are required, and compensatory planting may need to be undertaken. Removal of defective trees in an emergency situation, or self-seeded trees of an invasive or undesirable species, is not subject to the control requirements for tree removal, as stipulated in ETWB TC(W) No. 3/2006 (ETWB, 2006).

Where the retention of healthy trees is not practicable, consideration may be given to the possibility of transplanting them. Transplantation may, however, be very difficult to implement for trees located on some slopes, due to safe access and lifting considerations and the potential damage to other vegetation. The inclined rooting pattern common to trees on slopes may also greatly limit the chances of survival in new locations. Specialist advice should be obtained if transplanting is needed.

An effective means of limiting the overall impact on existing trees and other vegetation is the provision of effective supervision during the works. This, together with the proper implementation of establishment works, will have a significant contributory effect on the overall performance of landscape treatment works. Guidance on the supervision of landscaping works is provided in Chapter 7.

For private slopes, the requirements for tree preservation and management may be governed by the lease conditions.

2.2.2 Limiting Temporary Works

Temporary works and access for construction of slope works and engineering elements (e.g. drainage channels, stairways, berms, grillages for soil nailing), particularly those relating to natural terrain mitigation works, can have significant impact on existing trees and

vegetation beyond that of the permanent works. Measures to minimise these impacts should be sought. These should first be addressed in the design process, by carefully comparing the locations of temporary works with the tree survey findings to identify the least harmful arrangements. Careful supervision of temporary works during construction is also of the essence. General information on measures for the protection of existing vegetation is given in the *General Specification for Civil Engineering Works* (GS) (HKSARG, 2006), which include:

(a) establishing and maintaining protection zones around trees to be retained throughout the construction process,

(b) preventing contamination of soils from concrete or grouting works, drilling works, leaking of machine oils, etc., and

(c) temporary covering of tree roots and protection around tree trunks.

Site-specific requirements should be stipulated on contract drawings and in Particular Specifications (PS). Also, landscape treatment for reinstatement of the affected areas should be included in the landscape design.

2.2.3 Measures to Allow Retention and Protection

Where valuable trees or vegetation exist within the area of proposed slope works, measures that should be considered to allow retention include:

(a) Localised adjustment of the slope design to avoid removal of, or damage to, valuable trees or vegetation.

(b) Provision of retaining structures, e.g. local retaining walls, structural props or support guy ropes.

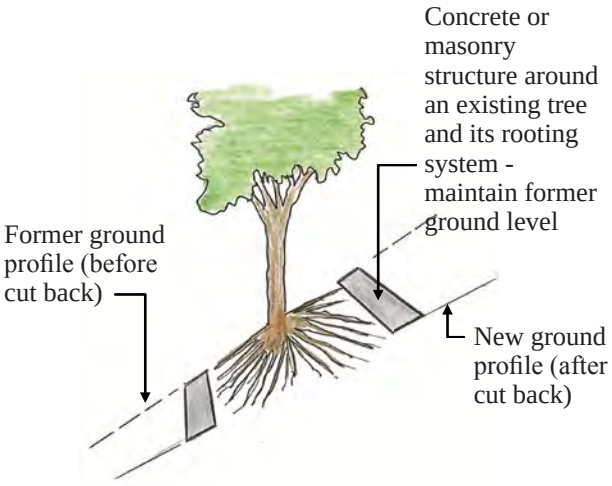
(c) Careful siting of engineering elements (e.g. soil nail heads and grillages, stairways, drainage channels) away from trees and their root systems.

(d) Provision of tree protection zones around trees to be retained, as recommended in the *Design for Tree Protection Zone* promulgated by DEVB (2010a). Excavation should not be carried out within these zones unless it complies with Clause 26.11 of the GS.

Examples of local design adjustments to protect trees are shown in Figure 2.1.

Tree ring openings should be provided in the design of hard surfaces to protect surface rooting systems near the trunk, and to allow air and water to reach the roots. Some standard drawings suggest the size of opening should be the diameter of tree trunk plus 600 mm, with additional space to allow for exposed tree roots. It is recommended that this dimension be

regarded as a minimum, and allowance should be made for the mature size of the tree and its surface rooting. Tree species vary considerably in their rooting patterns, but the large majority of tree roots in Hong Kong are generally located within a depth of 1 m below the ground surface. The lateral spread of the surface rooting of a tree may be similar to that of its canopy. In designing the size of a tree ring, the risk of local instability and erosion should be balanced against the advantage of providing a better condition for tree preservation.



(a) Localised wall at mid-slope designed to retain an existing tree and typical details

(b) Props supporting existing trees

(c) Localised wall extending into adjacent pavement to retain an existing tree

Figure 2.1 Retention of Existing Trees

Figure 2.2a illustrates a situation where the growth of surface roots has been severely constrained by a concrete surround. Where trees are closely spaced, tree rings should be combined into a single opening as shown in Figure 2.2b.

(a) Illustration of tree roots which have been constrained

(b) Combined tree rings forming single opening

Figure 2.2 Tree Rings

Trees on old masonry walls are of particular value and require special consideration, and the wall stability may be affected by them. Some tree species commonly found on masonry walls (e.g. *Ficus microcarpa* (Chinese Banyan)) have extensive rooting systems that can cover significant areas of the wall face, as well as extending into the surrounding ground. For works on masonry walls, the roots of existing trees should be carefully protected and special engineering details may need to be provided in the design, such as provision of intermittent buttresses to support the wall (see Figure 2.3a), or openings in a supporting toe slab to allow tree roots to extend into the ground (see Figure 2.3b).

Works that would inhibit the penetration of aerial roots into the adjacent ground should be avoided. The provision of narrow planting strips above and below a wall (see Figure 2.3c) would promote root growth and tree stability. Guidance on the protection of trees on masonry walls and recommendations on wall stabilisation measures are given in GEO Report No. 257 (Wong & Jim, 2011).

2.2.4 Minimising Visual Impact

The visual impact of new slope works can be reduced by blending them into the surrounding environment. The edge between the new slope face and the surrounding terrain may be especially visually prominent. The following measures can be adopted within the design to help merge the transition between a new slope and its surroundings:

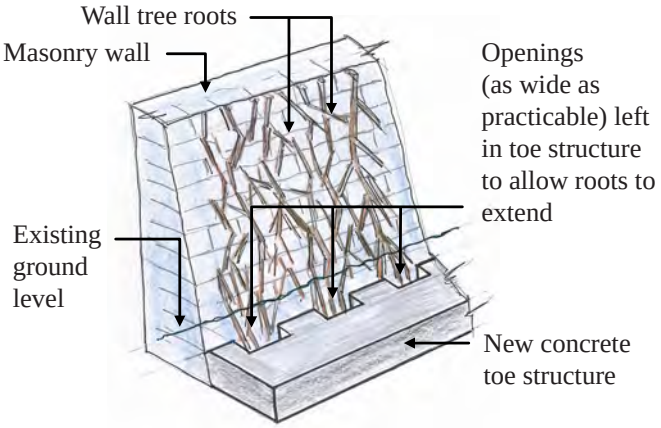
(a) varying heights between berms,

(b) rounding edges between new slopes and surrounding terrain,

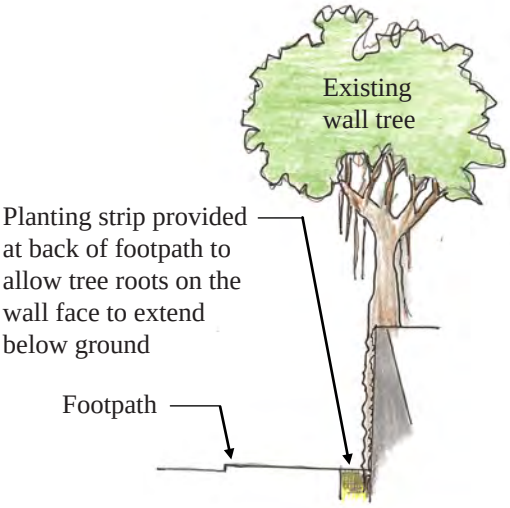
(c) non-geometric alignments of slope features (e.g. inclined berms, non-linear steps), and

(d) planting that overlaps the edges of new and existing slopes.

(a) Use of intermittent buttresses to support old masonry wall



(b) Openings in a new toe slab supporting the wall to allow continued growth of existing tree roots



(c) Provision of planting strips above and below masonry walls to promote root growth and tree stability

Figure 2.3 Retention of Wall Trees

Figure 2.4 and CEDD Standard Drawing C2105 illustrate examples of these measures.

Wherever possible, the alignment of drainage channels should be sympathetic to the natural ground contours and be located away from visually prominent edges.

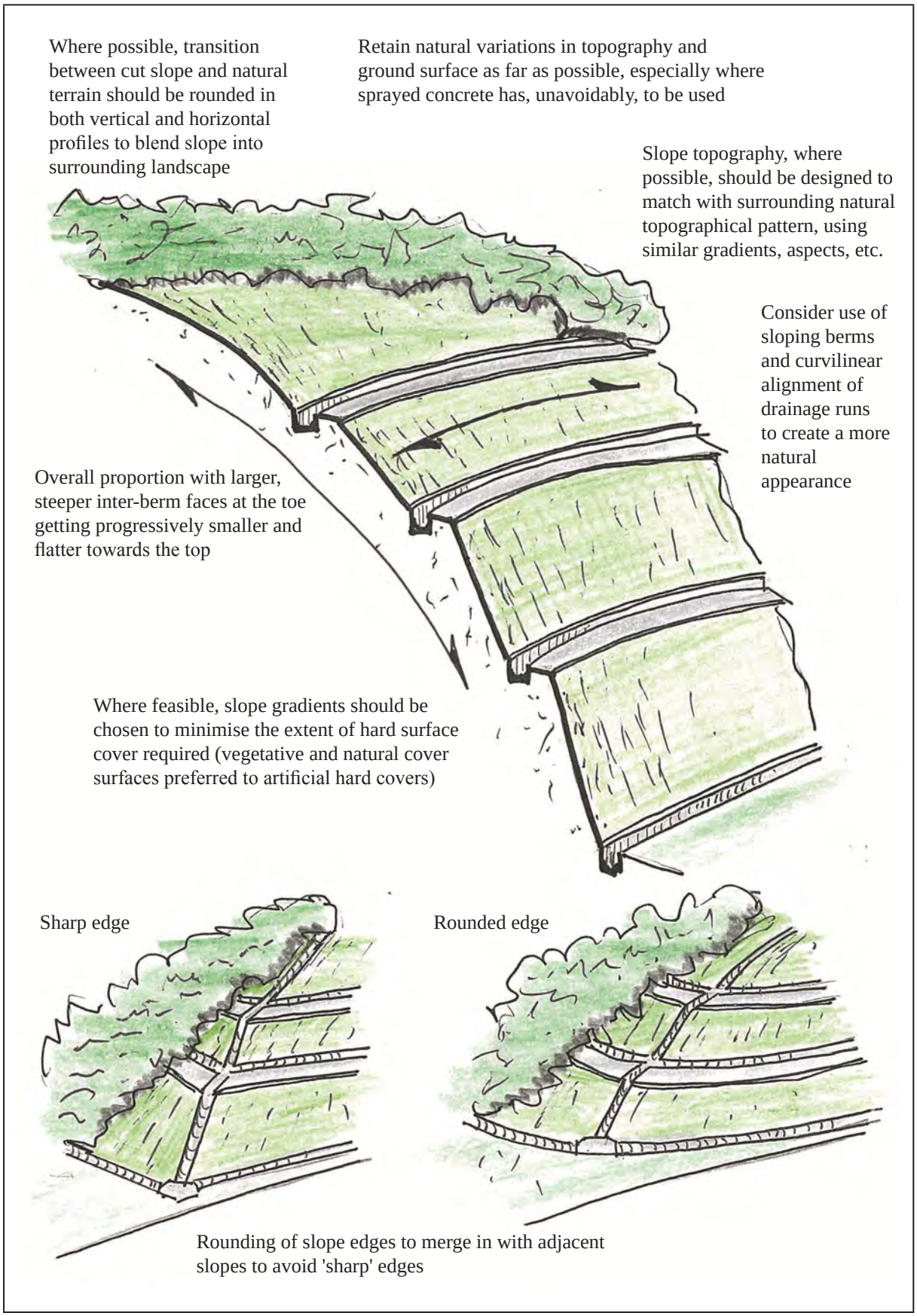


Figure 2.4 Slope Composition and Topography

As a general principle for high retaining walls, terracing or setting back of the upper portions of a wall will reduce the apparent scale of the wall and provide additional planting opportunities (see examples in Figure 2.5).

(a) Stepped gabion wall

(b) Stepped concrete wall

Figure 2.5 Reducing the Scale of Retaining Walls

2.2.5 Minimising Visual Impact of Engineering Elements and Slope Furniture

Slope engineering elements and slope furniture can be visually intrusive, especially when such works are 'over designed' (e.g. unnecessary drainage elements or excessive use of hard surfacing and maintenance access). Care should be taken with their use and locations in order to minimise the visual impact and create a more simple appearance. Improved detailing of engineering elements, together with the provision of screen planting and landscape hardworks (see Section 2.4), includes the following:

(a) inclined berms to minimise the size of drainage channels and the number of catchpits required (see Figure 2.4),

(b) shared facilities (e.g. a single set of access stairway) to serve adjoining slopes (see page 146 in Appendix C),

(c) buried soil nail heads and grillages on soil slopes (see page 131 in Appendix B),

(d) soil nail heads incorporated into hard slope structures (see Figures 2.11 and 7.2a),

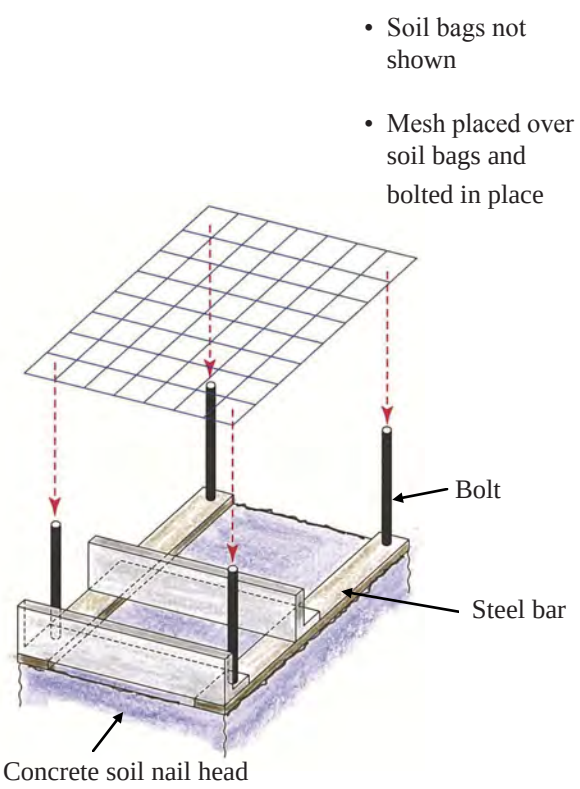
(e) baffle walls instead of catchpits (see Figure 2.7), and

(f) stairways placed in non-prominent locations, or following the existing topography (see Figure 2.13).

Soil nail heads may be recessed below the slope surface to allow room for biodegradable bags that are filled with soil for vegetation establishment (see page 135 in Appendix B). CEDD Standard Drawing C2106 shows the soil bags held in place by wire mesh, which is sometimes placed over the entire slope surface. The wire mesh may, however, restrict the growth of trees and shrubs (see Section 2.3.8). Figure 2.6 illustrates an improved detail to limit the extent of wire mesh to just the area of the soil nail head, thereby increasing planting opportunities for shrubs and/or trees over the remainder of the slope.

(a) Steel supports on nail heads

(b) Soil bags with mesh bolted in place



(c) Proposed engineering details

Figure 2.6 Alternative Arrangement to Support Soil on Nail Heads

The appearance of catchpits and drainage boxes to suit site circumstances should be duly considered in the design, rather than adopting standard details. The use of baffle walls may help to reduce the scale of visually unattractive elements. Figure 2.7a illustrates a catchpit extending into the adjoining pavement, which is visually unattractive. Figure 2.7b illustrates a similar circumstance, where a baffle wall has been used to minimise visual impact and nuisance to the public.

(a) Catchpit extending into pedestrian pavement

(b) Baffle wall at the edge of pedestrian pavement

Figure 2.7 Appearance of Catchpits and Baffle Walls

Concrete access stairways should be recessed into slopes where practicable. Stairways are normally provided at both ends of a slope following alignments of the drainage channels, from which they can provide access to berms. Designers should consider providing access stairways at one end of a slope only, particularly where the stepped channels are essentially self-cleansing.

Metal access stairways on rock slopes or retaining walls are often unsightly. Figure 2.8a shows an example where the steel access ladder could have been better located on the return face of the wall in order to reduce the visual impact. Figure 2.8b illustrates an example where access stairways have been integrated into the surrounding vegetation.

Gates for maintenance access can be unsightly and, other than providing a warning, may not be able perform the intended function (see Figure 2.8c). GEO Report No. 136 (Lam et al, 2003) suggests that access stairways and gates can be made less conspicuous by integrating them into the vegetated area and/or using smaller size structural members.

2.2.6 Improving the Appearance of Engineering Elements and Slope Furniture

Where slope features cannot be screened from view, their shape and arrangement should be designed in accordance with the basic design principles of:

(a) scale and proportion,

(b) pattern/order, and

(c) integration with surrounding rock/landscape.

(a) Visible access ladder at road side wall

(b) Stairway integrated into its surroundings

Notes:

- Careful detailing (a), by placing the ladder on the return portion, or providing a stone stairway on the adjacent slope
- Careful placement (b) of access stairways and screen planting
- Careful consideration (c), gate may serve little purpose and may be replaced by a warning notice (with the maintenance party's prior agreement)

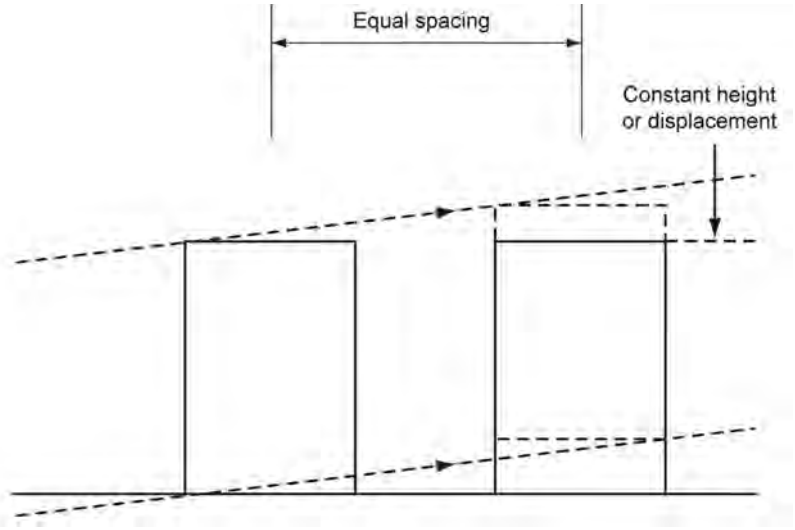
(c) Gate for access stairway

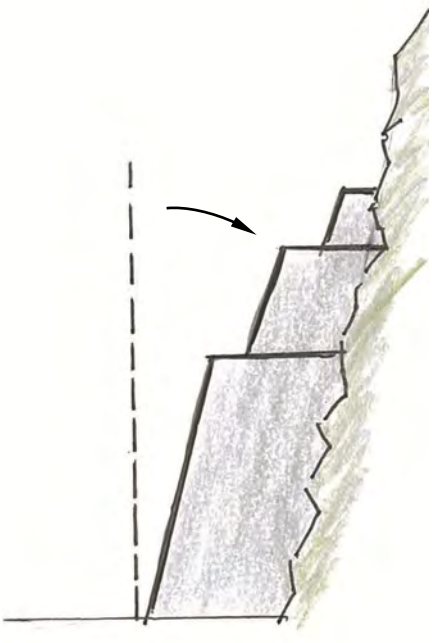
Figure 2.8 Mitigating the Visual Appearance of Maintenance Access

Buttresses can have considerable visual impact due to their size and proximity to viewers, particularly at the toe of a slope. Where practicable, the shape and geometry of buttresses should be designed with a view to reducing their apparent scale. Also, the form and proportion should be consistent to achieve a well co-ordinated family of elements (see Figure 2.9).

Where new soil nail (or rock bolt) heads are to be left visible, their appearance can be made more acceptable if the soil nails are installed in a regular pattern, as shown in Figure 2.10. Where soil nail heads are to be constructed on top of a hard surface, the shape of the nail head should be made more trapezoidal rather than cubic (see CEDD Standard Drawing C2522), or else the heads should be incorporated into a concrete skin wall.

- Adopt a consistent height, width and/or spacing
- Where there is an inclined base level, adopt an even displacement to maintain proportions
- For individual buttresses, the proportion of height to width should preferably be between 3:1 and 3:2

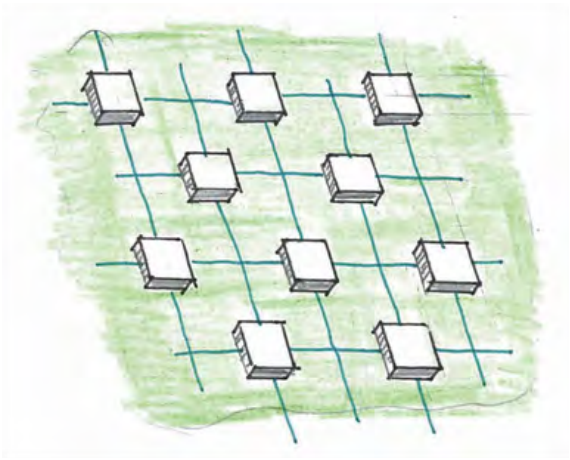




- Surface finish to match with surrounding rock/landscape where practicable (e.g. coloured/painted finish or masonry facing)
- Consider bevelled corner/edges for 'softer' appearance
- No-fines concrete has more texture/darker tone which can be visually appealing
- Inclined faces rather than vertical faces to give a more stable appearance

- Single large buttress preferred to many small ones
- Very high buttress features should be stepped to give them an appropriate scale and proportion

Figure 2.9 Shape and Form of Buttresses



- Adopt regular patterns for soil nail/rock bolt heads to reduce visual impact
- Minimise the size of soil nail/rock bolt heads as far as practicable

Figure 2.10 Layout of Soil Nail/Rock Bolt Heads

Figure 2.11a shows an example where the exposed soil nail heads have been incorporated in a decorative structure on an existing retaining wall, whereas Figure 2.11b illustrates soil nail heads that have been encased in a concrete grillage system.

(a) Exposed soil nail heads form decorative pattern

(b) Soil nail heads encased in a grillage system

Figure 2.11 Improving the Appearance of Exposed Soil Nail Heads

Gabion walls give a more natural appearance than concrete retaining walls, thus providing an attractive alternative especially in rural settings, such as Country Park. Figure 2.12 provides examples at Lantau and Choi Hung, which illustrate that exposed rock on the outer face of the gabion boxes can provide a more natural appearance. Wire used in gabion boxes is typically coated with PVC, the colour of which can be chosen to best suit the rockfill or the surroundings.

(a) Gabion wall adjacent to a minor road

(b) Establishment of vegetation on gabion wall

Figure 2.12 Use of Gabion Walls

Stairways formed of masonry blocks (see Figure 2.13) have a more natural appearance and should be considered for highly visible slopes, or those in sensitive settings such as Country Park.

(a) Access stairways built along an existing trail to minimise visual impact

(b) Masonry stairways blend in with the surroundings

Figure 2.13 Maintenance Access in Sensitive Site Settings

2.3 Landscape Softworks - Planting Works

2.3.1 Planting Design

In most situations, the goal of the planting design should be to create a sustainable vegetation cover, with low recurrent maintenance, which can promote the development of ecological habitats in the area, i.e. ecological planting.

Ecological planting can be achieved most easily through the planting of native species, as well as naturalised species which are known to have ecological value. This can create a vegetation cover similar to that of the surrounding vegetation (see Appendices E and F). DEVB (2010b) provides advice on the use of native species for particular situations.

The dispersal or invasion of plant species from adjacent terrain into a newly landscaped area is a continuous natural process, largely through seed dispersal by wind, water, birds and other animals. This is considered beneficial to the long-term sustainability of slope vegetation if the new species are from an area of native vegetation. The natural plant communities that exist in the area surrounding a slope are often a good indication of species which are likely to be sustainable.

However, there may be instances where invasive, or undesirable, species disperse or invade into a slope. As such, slope owners may request that these are removed during the Establishment Period, or alternatively have them removed later if they begin to dominate the intended vegetation.

Amenity planting commonly involves a mixture of exotic and native plant species. In general, it should only be applied on slopes that are isolated from natural vegetation, where dispersal or invasion of native species is unlikely.

Ornamental planting may be desired in some high visibility urban settings. However, regular intensive maintenance operations including watering, weeding, fertilization and pruning are needed to sustain the ornamental appearance. In addition, undesirable species may sometimes seed into the planting areas and disrupt the desired landscape appearance. Hence, ornamental planting should only be applied if long-term maintenance commitments have been agreed.

Figure 2.14 provides guidance on locations where ecological or amenity planting may be appropriate. Designers should satisfy themselves on their rationale for choosing ecological or amenity planting, with due regard to site-specific conditions and future maintenance needs.

2.3.2 Planting Techniques and Types

The following planting techniques have been widely used on slopes in Hong Kong:

(a) hydroseeding, which mainly includes grass seeds but may also include woodland mix seeds,

(b) pit planting of trees, shrubs, groundcover and climber plants,

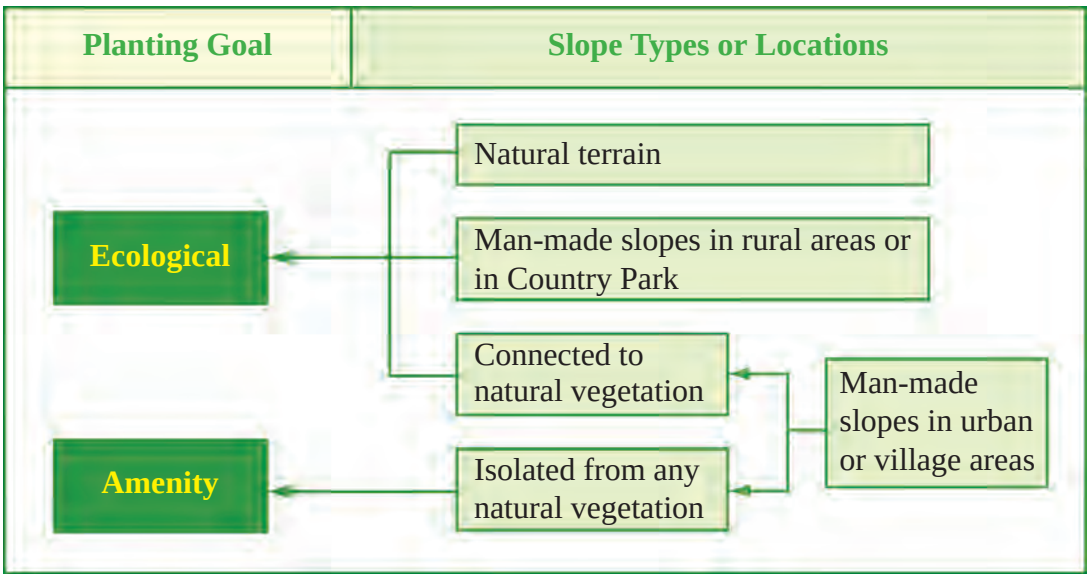
(c) bed planting of shrubs, groundcover plants in toe, berm and crest planters,

(d) core hole planting, similar to pit planting but using smaller planting holes for small shrubs, climbers and groundcover plants,

(e) notch planting of seedlings, commonly used for fern seedlings, and

(f) proprietary greening systems (e.g. mulching systems).

Further details on the above techniques are provided in Table 2.1.



Notes:
(1) Natural vegetation may be considered to include natural woodland and areas of mature planting.
(2) Ecological planting may be considered for isolated slopes, if these are sufficiently large, even without the presence of adjacent native woodland.

Figure 2.14 Application of Planting Goals for Planting on Slopes

The selection of planting techniques and species are affected by site conditions (i.e. availability of soil, water and light to support the successful establishment and growth of plants), types and conditions of surrounding vegetation, the landscape objective and goal of the planting (see Section 2.3.1). A proper understanding of the site setting is essential to assess these factors and specialist input by a landscape architect is needed. Appendix E presents a methodology for plant selection and lists of potential species to meet particular site conditions. Appendix F provides further details on suggested plant species.

Shrubs should be planted in groups of 3 to 5 of the same species spaced at 1.0 m to 1.5 m. In order to minimise the need for long-term maintenance of landscape works, spacing of trees should take into account the likely spread of the tree crown when mature. Depending on the size of the tree at the time of planting, provision of temporary stakes and/or guy wires support may be required during the Establishment Period. Reference could be made to Clause 3.61 of the GS.

Table 2.1 Typical Planting Techniques for Slope Works

Planting Technique	Description
Hydroseeding (GS Clause 3.69)	A mixture of grass seed (or less commonly grass/tree/shrub seeds), mulch, fertilizer, soil binding agent, and a vegetable dye in an aqueous suspension, applied by high pressure spray onto a soil surface. It is the most common method of establishing grass on slopes in Hong Kong and can be used on very steep gradients. It often serves as a pioneer species to accommodate later natural dispersal or invasion of species from adjacent hillsides. It is also used to seed some proprietary products applied to hard slope surfacing.
Pit planting (GS Clauses 3.64 - 3.68)	Planting in pits excavated into an in-situ or placed soil. Pits are backfilled around the plant with soil-mix comprising soil, mulch and fertilizer. The size of the pit depends on the size of vegetation to be planted. Guidance is provided in the GS (HKSARG, 2006). Pit planting on soil slope steeper than 45° is not recommended due to the extent of disturbance of the slope surface required, and because of the increased risk that the backfilled soil may be washed way.
Bed planting	Planting into soil-mix that has been placed within the toe, berm or crest planter.
Core hole planting in hard surface cover	Similar to pit planting, except that the core hole is usually smaller in size (around 300 mm in diameter with some 30 litres of soil-mix, see CEDD Standard Drawing C2507). It is commonly used for planting climbers on steep slopes, especially those with a hard surface cover.
Notch planting (GS Clause 3.63)	Seedlings of ferns, groundcover plants and climbers are planted in a notch cut into the slope surface, typically spaced at around 500 mm in a staggered arrangement. Root tube planter (see Section 2.5.2), which is a proprietary product, provides a similar function.
Hydro-mulching or other proprietary greening techniques	Various proprietary products/techniques which involve a thin layer of mulch/soil-mix, many with supporting structures, applied to steep slopes including those with hard surfacing. Either plant seeds are incorporated into the mulch/soil-mix, or climbers and groundcover are planted into pockets within the applied layer.

The selection of planting type is also heavily dependent on slope gradient. Figure 2.15 and Table 2.2 provide guidelines on planting types that are generally applicable to slopes for various ranges of slope gradients. However, these are not mandatory and designers should exercise judgement in determining the most appropriate design to cater for site-specific conditions.

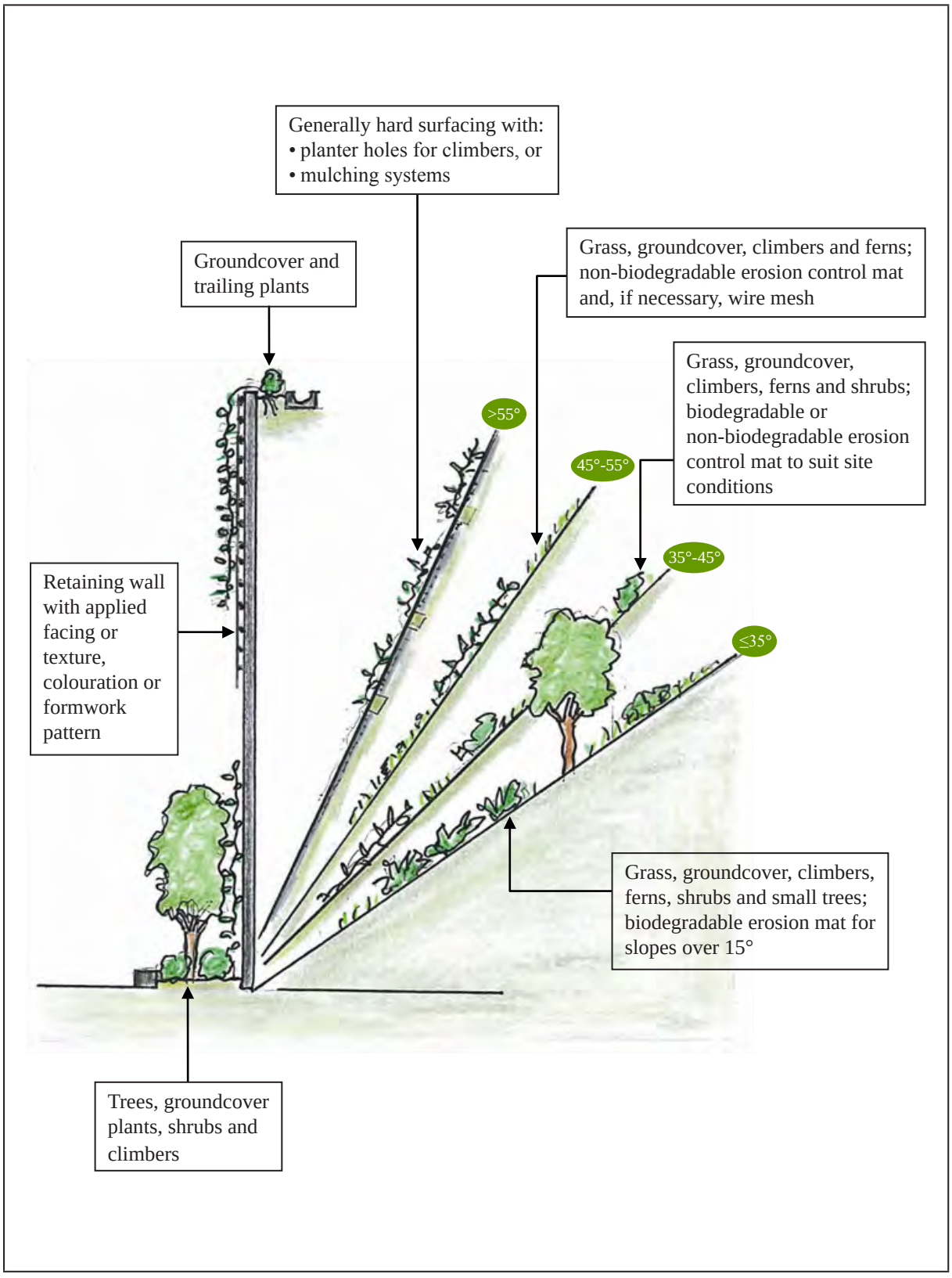


Figure 2.15 Guidelines for Planting and Erosion Control Measures Based on Slope Gradient

Table 2.2 Guidelines for Planting and Erosion Control Measures Based on Slope Gradient

Slope Gradient (θ)	Possible Planting on Slope Face	Examples of Suitable Erosion Control Measures
$\theta \leq 15°$	**Ecological Planting**: Grass hydroseeding with pit planting of native species, including trees (smaller varieties preferred), shrubs, groundcover, ferns and climbing plants, or **Amenity Planting**: Grass hydroseeding with pit planting of native and exotic trees, shrubs, groundcover and ferns.	No particular requirement.
$15° < \theta \leq 35°$	Grass hydroseeding with pit planting of small trees (up to about 3 m height when mature), shrubs, groundcover, ferns and climbing plants.	Biodegradable erosion control mat.
$35° < \theta \leq 45°$	Grass hydroseeding with pit planting of shrubs, groundcover, ferns and climbing plants.	Biodegradable erosion control mat at shallower angles or non-biodegradable erosion control mat to suit site conditions.
$45° < \theta \leq 55°$	Grass hydroseeding with groundcover and climbing plants in root tube planters.	Non-biodegradable erosion control mat, with wire mesh if needed to suit site conditions.
$\theta > 55°$	Core hole through hard surface cover for planting of groundcover and climbing plants.	Non-biodegradable erosion control mat, together with wire mesh, up to about 60° if ground conditions are suitable and the upslope catchment is small, thereafter hard surface cover or proprietary green surface system, where conditions permit and long-term maintenance commitments have been agreed.

Notes:
(1) Toe planters for planting of trees, shrubs and climbers should be adopted where practicable as they are an effective means to screen slopes and retaining walls. Native species, if used, will add biodiversity and have overall environmental benefits.
(2) Appendix E gives guidance on selection of plant species.

The use of vegetation, particularly on steeper soil cut slopes, carries a risk of small-scale erosion failures (e.g. shallow washout). The risk should be balanced against the benefit of providing greener and environmentally sustainable slopes. The appropriate choice of planting techniques and vegetation species, together with the use of proper erosion control measures, may help to reduce such risk. Also, adequate drainage provisions should be provided to prevent uncontrolled surface water flow from upslope areas.

Many man-made slopes, especially cut slopes, are steep and the planting of trees should be exercised with caution. Where new trees are to be planted on slopes up to 35°, it is recommended that only species with small crown are used.

After completion, planting works are subject to an Establishment Period, typically 12 months. Within the Establishment Period, the contractor is required to provide horticultural care and maintenance of all plants to ensure their healthy establishment and growth. Reference may be made to Clauses 3.79 to 3.93 of the GS for the responsibilities of the contractor in this regard.

2.3.3 Soils for Planting

Soil and rock slopes in Hong Kong are typically composed of saprolitic soils and rock, defined by the parent rock from which they are derived and a material decomposition grade (GCO, 1984). While some man-made soil slopes are composed of residual soil (Grade VI weathering grade material), the majority are devoid of topsoil and comprise saprolitic soils (Grade V and/or Grade IV material). They are also generally nutrient poor (SILTech, 1991). Saprolitic soils, in combination with soil conditioner (i.e. organic materials such as coir, green compost or bio-solids), may serve as a soil-mix for planting. Reference can be made to Clause 3.30 of the GS for details.

Sufficient depth of Grade V and Grade VI soils can support large shrubs and possibly trees. For safety reasons, small tree species (see Section E.2.3 in Appendix E) are preferred rather than medium or large tree species. Where the soil is thin (<300 mm) or relatively hard as a planting medium (e.g. Grade IV material), the use of grass, groundcover, climbers or small shrubs should be considered and tree planting should be avoided due to potential stability issues. Table 2.3 provides guidance on minimum and preferred soil depths for various types of planting.

Table 2.3 Soil Depths Needed to Support Different Vegetation

Vegetation Type	Minimum Depth of Existing Soil or Placed Soil-mix Material over Inert Rock/Rockfill Substrate	Preferred Soil Depth
Grass	150 mm	300 mm
Groundcover/ Climbers	300 mm	600 mm
Shrubs	450 mm	900 mm
Trees	800 mm	>1200 mm

On mixed soil and rock slopes, soil depths and conditions may vary considerably over the slope. It is recommended that vegetation to be planted on such surface should be limited to grass and groundcover plants that have a shallower rooting system. *Wedelia trilobata*, for

example, may be used for this purpose because it has a high tolerance for sites with poor soil conditions or adverse setting. However, its invasive characteristics may inhibit successful establishment of other plants. Therefore, the use of *Wedelia trilobata* is generally not recommended for sensitive sites, such as Country Park.

Where soil-mix is placed in planters or in planting pockets, compaction is generally not required, although some soil settlement would be anticipated. The sub-surface drainage layer inside the planter box should be properly constructed before backfilling with soil-mix.

Where soil-mix is placed as an overlay layer (e.g. over soil nail grillages or rockfill), a minimum thickness of 150 mm is recommended and it may need to be lightly compacted to achieve sufficient mass strength. On steeper slopes (e.g. between 35° and 45°), an erosion control mat should be placed over the soil-mix to hold it in place and/or a small percentage of cement (2% to 5%) may be added to the soil-mix to increase its strength. Additional measures may be required to prevent soil slumping (e.g. provision of wire mesh to support an erosion control mat).

For planting in gabions, soil-mix in biodegradable bags can be incorporated in the gabion boxes, for planting of climbers and groundcover plants. The minimum soil volume in these soil bags should be around 15 to 20 litres. Figure 2.12b shows the use of such soil bags in a stepped gabion wall.

In-situ and placed soil is subject to surface erosion. Although planting can have bioengineering benefits in erosion control, the contribution is difficult to quantify. Designers should ensure that adequate measures are adopted to prevent erosion, both while planting is establishing and in the long term. Figure 2.15 provides guidance on the use of erosion control measures by slope angle. As erosion control measures may affect the type of planting that can be established, their use should be considered early in the design process. Details of different erosion control products are given in Section 2.3.7.

2.3.4 Other Requirements for Planting

The amount of water in the soil available for plants, the effects of wind and air pollution, and the availability of sunlight are factors which designers should consider in the selection of planting species. Table 2.4 presents aspects which need to be considered. Preparation works necessary for planting are given in Clauses 3.49 to 3.68 of the GS.

2.3.5 Planting Season

The appropriate period for planting in Hong Kong is in general from March to the end of August (see Figure 2.16). Planting should, wherever possible, be carried out during the planting season. Depending on weather conditions, planting outside of this period may lead to significantly lower plant survival rates, especially if watering is not carried out regularly during the Establishment Period. Designers need to consider the appropriate frequency of watering to ensure successful establishment of vegetation.

Table 2.4 Water, Air and Sunlight Needs for Planting

Element	Consideration	Factors to Consider
Water	Supply of water to soil	• Amount of rainfall reaching the soil, particularly if the slope is sheltered by overhead structures. • Infiltration rate and the effectiveness of surface drainage systems. • Nature of the underlying strata and groundwater conditions.
	Retention of water in soil	• Depth/volume of soil. • Soil particulate structure and porosity.
	Drainage	Soil drainage is of equal importance to water supply for plants. Too much water can be as damaging as too little. Soils need to be free draining, and should not be allowed to flood as this will create anaerobic conditions in the soil, i.e. oxygen getting to the roots via the soil pore spaces. The provision of sub-soil drainage in toe and berm planters is essential.
Air	Location	Airborne pollution could be an issue for slopes close to major highways. Sites in close proximity to the sea may be subject to salt water spray and the selection of plant species will need to take this into consideration.
	Wind	• Windy conditions can inhibit plant growth, e.g. on very exposed slopes, or at locations where wind is channelled. Pioneer species can be used to modify the micro-climate conditions to favour slow growing native plants. Removal of pioneer species may be required before they become dominant, and designers should ensure that the necessary long-term maintenance commitments are in place before opting for this approach. • The potential wind loading on an existing tree may become an issue where surrounding trees have been removed.
Sunlight	Slope orientation and elevation	Exposure to sun and drying winds; slope orientation and elevation may have notable effects on the growth rate of vegetation, due to their relative exposure to the sun and wind.
	Shading	Most vegetation species in Hong Kong are high light-demanding, the growth rate of which may be limited on shaded slopes. Shade tolerant species should be used for planting on slopes where light levels are expected to be low, e.g. on slopes that have been shaded by adjacent structures, or consist of overhanging vegetation, especially for north-facing slopes.

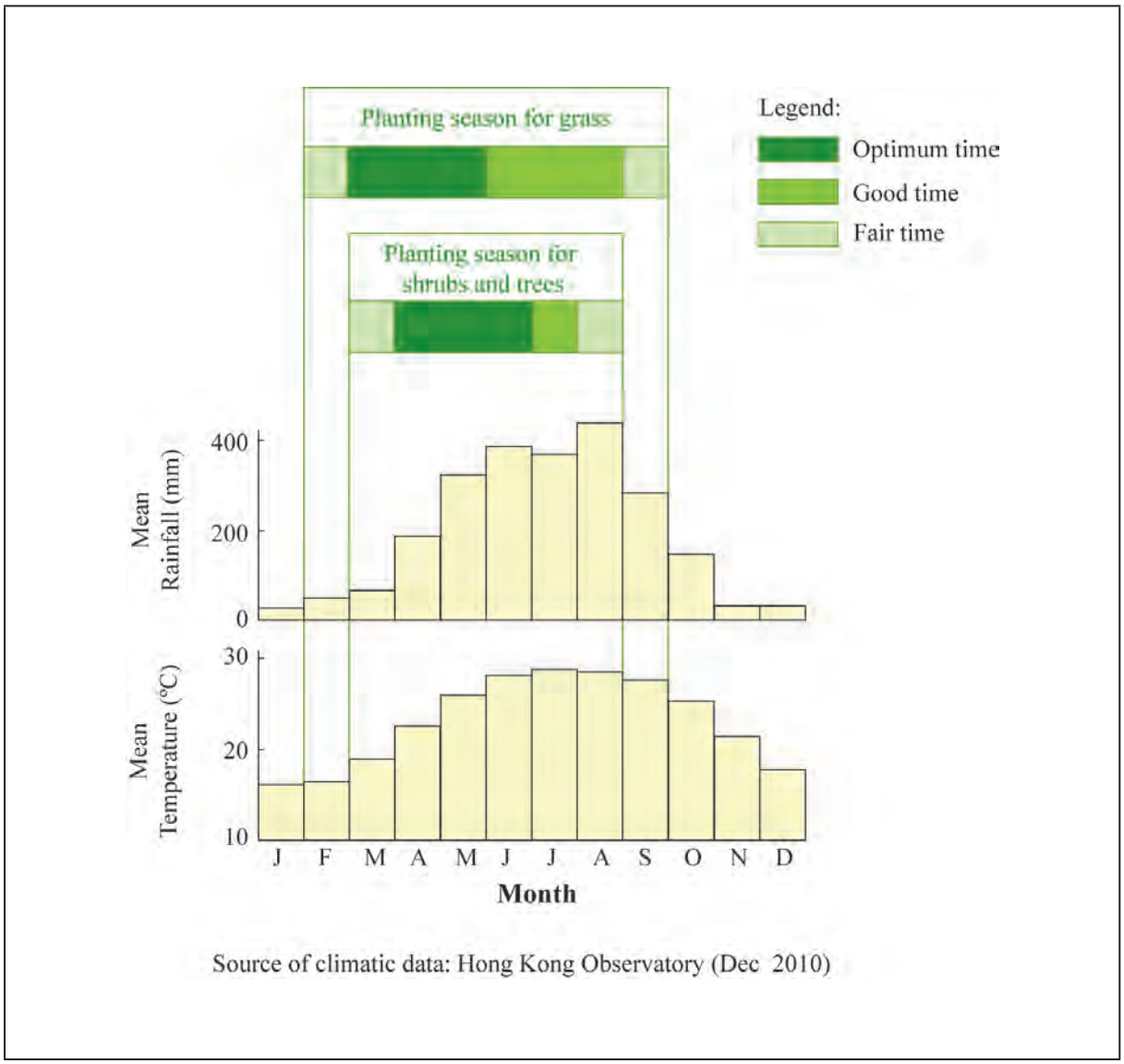


Figure 2.16 Recommended Planting Season in Hong Kong

The works programme must allow sufficient time, preferably within the planting season, for the planting works. The completion of planting works should be regarded as essential to substantial completion of the works programme.

2.3.6 Planters and Planting Holes

Planters at the toe, on berm or at the crest of a slope can create opportunities for additional planting, and can be particularly effective in reducing the visual impact of hard surfaces or concrete elements. Plants should be selected to suit the size of the planter. If artificial watering cannot be provided, hardy species should be selected which would have a higher survival rate. Guidance on the necessary depth of soil-mix is given in Table 2.3. The planter width required should allow for the spread of the mature root system, where practicable. Spacing of trees and shrubs should generally follow the guidance for pit

planting (see Section 2.3.2). Climbers can be spaced at around 2 m centres and groundcover plants spread at around 6-8 per square metre across the planter.

Figure 2.17 illustrates various applications of toe planters. If the slope toe line is inclined, the planter can be constructed in steps as illustrated in Figure 2.17d.

(a) Climbers used to screen a sprayed concrete cut slope

(b) Toe planter in urban setting improves visual appearance of the slope

(c) Shrubs and trees used to screen an existing retaining wall

(d) Stepped planters reduce loss of soil-mix and standardise the wall heights

Figure 2.17 Various Applications of Toe Planters

CEDD Standard Drawings C2001, C2002 and C2007 provide details of concrete planters, masonry facing to concrete surfaces and masonry stone planters, respectively. These should be adjusted to suit particular site conditions, as appropriate.

Figure 2.18 illustrates retaining structures with trailing plants at the upper portions, which provide a pleasing green finish. Setting back of the crest channel may be considered to provide space for planting of trailing plants and groundcover plants, as illustrated in Figure 4.15.

Figure 2.18 Trailing Plants Growing from the Crest of Retaining Walls

Pockets of soil-mix (see core hole planting in Table 2.1) can often be incorporated within hard surfaces to provide opportunities for planting of climbing species, thereby improving slope appearance. Vegetation species selected for core hole planting should be hardy species which can survive with minimal artificial watering.

2.3.7 Surface Erosion Control Products

Erosion control products are generally applied directly on the exposed soil surface to improve its resistance against soil erosion by slowing down the flow velocity, and by cushioning the impact of raindrops loosening the soil. Different types of erosion control products are described in Table 2.5.

Table 2.5 Typical Erosion Control Products for Slope Works

Product	Description	Application
Biodegradable erosion control mats	Typically these comprise a woven mesh made of natural materials, such as coir, jute or coconut fibres. They provide a temporary means to hold soil and plant seeds in place and prevent erosion until vegetation has become established. In general, they will degrade within a period of 3 to 5 years.	To be used where the vegetation itself, once established, will be able to resist surface erosion.
Non-biodegradable erosion control mats	Synthetic products, commonly high-density polyethylene (HDPE), usually manufactured in three-dimensional matrices that help to retain and entangle soil and plant roots. Available in a range of colours, most commonly black or green.	Particularly suitable for slopes >35° where vegetation alone may not provide sufficient erosion protection.
Wire mesh	PVC coated galvanised steel wire, minimum diameter 2.2 mm, woven into a triple twist hexagonal mesh and fixed onto the slope surface by means of anchor bolts and/or fixing pins.	Particularly suitable for steeper slopes where wire mesh is used to hold the underlying erosion control mat on slope surface, which provides a more effective means of controlling surface erosion. If erosion occurs, debris will be trapped under the erosion control mat.

Erosion control products can also be beneficial to the successful vegetation establishment by helping to retain soil moisture, moderating the surface temperature of the seed bed, protecting developing root and stem systems, and providing reinforcement to mature vegetation (Lui & Shiu, 2006).

There are, however, some potential drawbacks in using erosion control products which may need to be considered in their selection. Some non-biodegradable erosion control mats are tightly woven, making it difficult for grass seed to root into the underlying soil. The matting can sometimes strangle plants as they grow, and the more open weave products are better in this regard. Biodegradable erosion control mats are not generally used on slopes where vegetation alone may not provide sufficient erosion protection, because they degrade within 3 to 5 years and cannot provide long-term erosion control.

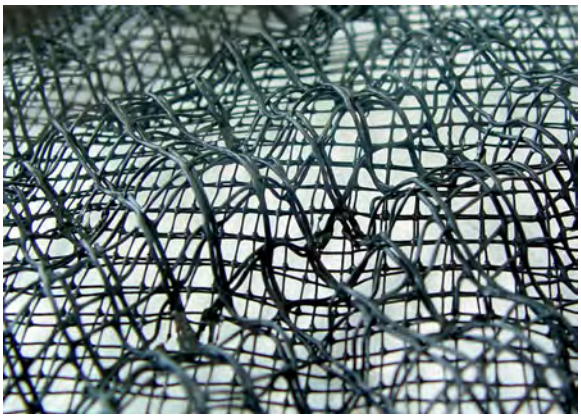
The use of non-biodegradable erosion control mats on steeper slopes, as opposed to a hard surface, also carries a risk of occasional small-scale failures (Ng et al, 2008). However, this should be balanced against the benefits of providing a vegetated slope.

In practice, some non-biodegradable erosion control mats do partially degrade over time, such that they can be fairly easily split by vegetation growing through them. As far as vegetation establishment is concerned, this may be seen as an advantage. Examples of erosion control mats are given in Figure 2.19.

(a) Biodegradable erosion control mat

(b) Non-biodegradable erosion control mat

(c) Close-up of biodegradable erosion control mat



(d) Close-up of non-biodegradable erosion control mat

(e) Wire mesh over non-biodegradable erosion control mat

(f) Close-up of the wire mesh over non-biodegradable erosion control mat

Figure 2.19 Erosion Control Mats and Wire Mesh

2.3.8 Wire Mesh Support to Erosion Control Mat

The prime purpose of wire mesh (typically specified as triple twisted PVC coated wire) is to help prevent or minimise shallow or washout type failures. This is achieved by anchoring the mesh to the slope (e.g. to soil nail heads). It also serves the function of supporting the erosion control mat for steep vegetated slopes. Some standard drawings (e.g. CEDD Standard Drawing C2106) also suggest its use to support erosion control mat on slopes with a soil overlay.

Wire mesh can severely restrict the growth of trees and shrubs as they attempt to grow through the mesh. Figure 2.20 illustrates a situation where wire mesh has become embedded into the trunk of a self-seeded tree, creating a potential structural weakness in the tree. The tree has also lifted the mesh off the slope face, so that it no longer holds down, or supports the underlying erosion control mat.

Figure 2.20 Unsatisfactory Interaction of Wire Mesh and Vegetation

The wire mesh should be cut at the time of planting to accommodate potential growth of trees. Owing to access difficulties, cutting during routine maintenance may be impractical. The extent of cutting needs to be sufficient to allow unconstrained growth of the trees.

Designers may consider possible alternative materials to the triple twisted PVC coated steel mesh, in order to achieve the necessary support to the underlying erosion control mat. Other products such as high tensile wire mesh or synthetic plastic geogrid, which have larger grid openings than the standard wire mesh, may be less restrictive to the vegetation and may offer some advantages in terms of ease of placement and cutting. In supporting the erosion control mat, closer spacing of fixing pins may be implemented to eliminate the need for other supporting measures. A possible arrangement to limit the extent of wire mesh is given in Figure 2.6.

2.4 Landscape Hardworks - Aesthetic Treatment of Hard Surfaces

As discussed in Section 2.2.5, careful design of engineering elements and slope furniture can significantly reduce their visual impact. Application of landscape hardworks together with landscape softworks (see Section 2.3) can possibly provide a more visually pleasing appearance for the concrete elements. These are broadly categorised below as concrete or metalwork elements.

2.4.1 Concrete Elements

Typical concrete elements used in slope works include: sprayed concrete, retaining walls, buttresses, facing panels, berms and access stairways, soil nail heads and grillage beams, drainage channels and catchpits, planters and rigid barriers for natural terrain mitigation measures.

Table 2.6 provides a list of possible techniques to improve the visual appearance of concrete elements and masonry blockworks, which include concrete formed and unformed surfaces, common graphic patterns, applied facings and colouration. Other less common options include the use of proprietary liners within standard formwork, precast panels and cladding systems and facings of artificial rock. Where these less common options are considered, specialist advice should be sought as a high level of workmanship in manufacture and application is usually required. They may also be expensive and difficult to replicate.

Treatments on concrete elements will need to be agreed with the client and maintenance agent, as they will affect construction and maintenance costs. Illustrations of some treatments are provided in Appendix C. For roadside retaining walls, in particular for projects involve a significant number of such structures, referral to the Advisory Committee on the Appearance of Bridges and Associated Structures (ACABAS) of Highways Department may be necessary regarding the aesthetics, visual and greening aspects (ETWB, 2004a).

Designers are reminded that when specifying the use of masonry, blockwork, tiling or similar finishes for retaining walls, outlets of weepholes or other drainage pipes should be properly connected. Otherwise, groundwater may seep into gaps between the wall and the surface finish. This will lead to a build-up of water pressure, which may result in de-lamination of the surface finish. For high retaining walls where such finishes are proposed, consideration should be given to specifying concrete beams to act as lintels, which will help to support the surface finish. This will also have the added benefit of reducing the scale and proportion of the wall structure.

2.4.2 Metalwork Elements

Metalwork elements include access ladders, wire mesh, handrailings, gates, slope registration plates, flexible barriers for natural terrain mitigation measures, etc.

Safety handrailings generally follow the details provided in CEDD Standard Drawing C2103. GEO Report No. 136 (Lam et al, 2003), however, has shown that smaller diameter tubing may be less visually intrusive, yet still satisfy safety requirements. The use of flat bars may also be considered as an alternative. Figure 2.21a provides an example of the use of small diameter handrailing tubes. 'Artificial wood' style railings have been used in Country Park and might be considered for slope works in similar settings.

Metalwork may be left as a galvanised finish, or painted with a suitable colour sympathetic to the surroundings. GEO Report No. 136 (Lam et al, 2003) suggests possible colour schemes for handrailings to soften the appearance of the elements.

Table 2.6 Common Landscape Hardworks to Concrete Elements

Type	Treatment	Guidance
Surface finishes	Standard formwork finishes	Defined in Table 14.1 of the GS. Finishes vary from F5 (smoothest) to F1. Table 14.4 of the GS suggests situations for use.
	Screed, brushed or floated finishes to otherwise uniform surfaces	Defined in Table 14.2 of the GS. Finishes vary from U5 (smoothest) to U1. Table 14.4 of the GS suggests situations for use.
	Exposed aggregate finish	Finish T1 is described in Table 14.3 of the GS. The concrete surface is washed and brushed before fully hardening to expose coarse aggregates.
Simple graphic patterns	Block pattern finish	CEDD Standard Drawing C2003 provides details. Normally used with F3 or F4 formwork.
	Ribbed finish	CEDD Standard Drawing C2003 provides details. Used with F3 formwork.
	Fractured rib finish	Fragments of ribbed finish are hammered or chiselled off to provide fractured effect. A high standard of workmanship is required.
Coloration	Painting	A full spectrum of colours is available which can be applied by brush or spray. Colours may fade over time.
	Pigment in concrete	May be difficult to achieve a consistent appearance in large areas and to replicate.
Applied facing and texture	Stone masonry blockwork	CEDD Standard Drawing C2002 provides details. In general, larger sized masonry blocks should be used at the base with smaller sized blocks higher up to provide visually more comfortable scale and proportion. Blocks of different colours or protruding blocks at random locations could also be used to break up the surface treatment and avoid a monotonous appearance, as Figures 1.1(e) and 1.1(f) as well as Appendix C illustrate. On large retaining walls, horizontal concrete beams can be used in the face as lintels to break up the massive scale and provide intermediate support to masonry facing, as Figure 4.15 illustrates. Block size, colour and pattern of masonry and/or rock should be compatible with the existing masonry and/or rock faces which remain exposed after the slope works.
	Tiling	Ceramic tiles and reconstituted stone tiles can be used on retaining walls, buttresses and toe/berm/crest planter walls, either on their own or in combination with other materials, to achieve a high quality finish. Suitable for use in high visibility urban situations where slope elements need to visually tie in with the surrounding structures.
	Epoxy based features	Proprietary products comprise epoxy paint and granular particles, the surface pattern of which could be similar to that of random packed granite stone facing.

Slope registration plates should be located in discrete areas, preferably below eye level and not to be blocked by vegetation.

Wire mesh should be coated with a PVC corrosion protective material, which is available in a variety of colours. The choice of colour should best suit the surrounding environment or matting material beneath the wire. Figure 2.21b shows an appropriate coloured mesh for a rock slope.

(a) Small diameter (35 mm OD) tube used as handrails

(b) Appropriate coloured wire mesh for an existing rock slope

Figure 2.21 Minimising the Visual Impact of Metalwork Elements

2.5 Proprietary Systems and Products

Proprietary systems currently used in slope works broadly comprise various forms of surface mulching systems and proprietary planting techniques.

Some proprietary systems are designed for specific slope applications, whereas others are applicable across a range of conditions. In selecting any proprietary system, factors such as cost effectiveness, long-term performance and future maintenance requirements should be considered. Designers should satisfy themselves that the proprietary system is appropriate and cost effective for the specific slope condition and setting. The use of proprietary systems, particularly on the recurrent maintenance requirements, will need the prior agreement of the maintenance agent.

2.5.1 Surface Mulching Systems

A number of techniques have been developed for establishing vegetation on steeper slopes, or where there is a hard surface cover, as described in Table 2.7. Examples of these proprietary systems in use are shown in Figure 2.22. Surface mulching systems are commonly applied on hard surfacing, and may perform better if applied directly to natural ground.

Table 2.7 Typical Proprietary Surface Mulching Systems for Slope Works

System	Description	Application
Sprayed mulching systems	These systems involve one or more layers of mulch or soil-mix applied onto the slope surface. Mulch and soil-mix vary in type, composition and additives. They generally have little tensile, compressive and shear strength. Some systems use a layer of steel wire mesh and/or one or more layers of erosion control mat to strengthen the mulch or soil-mix layer.	Most sprayed mulch systems can be applied on uneven slope profiles to form smooth finished surfaces, hence are suitable for slopes which may have an irregular surface. Cracks in the mulch or soil-mix layer associated with desiccation and down-slope movement of the mulch or soil-mix have been observed on some slopes.
Cellular systems	These are systems with compartments or panels to contain mulch or soil-mix on the slope face. In some products, the mulch or soil-mix is embedded into the slope, exposing the top surface for planting purposes. The panels may be encased in a wire mesh containment system.	Some products allow vegetation to be pre-grown in the mulch or soil-mix panels (in the nursery) before being installed on the slope face. These provide an instant effect. However, the small isolated panels of mulch or soil-mix may dry up and result in poor growth or plant failure. Without a dense vegetation cover, the panels and wire mesh are visible and can be unsightly.
Reinforced soil systems	These are similar to sprayed mulch systems but involve spraying the soil-mix onto the slope face whilst simultaneously applying continuous synthetic fibres to the soil-mix.	The use of reinforcement permits a thicker layer of soil-mix to be constructed on steep slopes. The thicker soil layer can sustain plants longer in dry conditions and can support the growth of small shrubs.
Note:	Table 2.7 is a summary of the recommendations given in GEO's TGN No. 20 (GEO, 2007).	

(a) Well established surface mulching system

(b) Cellular system in relatively shaded area

Figure 2.22 Surface Mulching Systems

The following measures are recommended to enhance the stability of the mulch, or soil-mix layer in surface mulching systems:

(a) Provide a concrete or masonry apron to stepped channels to prevent erosion by splashing of water (CEDD Standard Drawings C2409 and C2410 refer).

(b) Provide a suitable long-term non-biodegradable erosion control mat for products that do not include any form of surface erosion control.

(c) Apply a layer of PVC coated wire mesh to the final surface to support mulch or soil-mix layer. The mesh should be slightly stretched to ensure close contact with the slope.

(d) Protect the edges of the mulch or soil-mix layer from surface erosion by erosion control mats wrapped around the mulch.

(e) Provide a concrete kerb or planter wall to support the toe of the mulch or soil-mix layer and to help prevent its down-slope movement.

Surface mulching systems generally provide only a relatively thin mulch or soil-mix layer, typically less than 100 mm. This cannot support large or deep rooted vegetation. Smaller plants such as grass, groundcover, climbers, ferns and other herbaceous types should therefore be used. The mulch or soil-mix layer may contain seeds which will germinate and grow after installation. More commonly, vegetation is established by using a hydroseed mix which may contain shrub seeds.

Figure 2.23 Common Appearance of a Sprayed Mulching System during Dry Season

Plant species should be selected with respect to the criteria presented in Section 2.3.2, and based on good examples of the same system being used in similar environmental conditions.

A key limitation to the use of surface mulching systems is that the vegetation can dry out, particularly during the dry season on exposed south-facing slopes, as shown in the example in Figure 2.23. Regular watering may be required during the dry season, or other dry periods. Besides watering, other recurrent maintenance requirements (e.g. replenishment of mulch and/or

fertiliser) need to be taken into account when deciding on the appropriateness and cost effectiveness of these systems.

2.5.2 Root Tube Planters

Root tube planters are another proprietary product that has been used to facilitate vegetation establishment, especially ferns, climbers and small shrubs in harder soils which may otherwise be difficult to vegetate. Figure 2.24 shows an example during installation.

The tubes comprise perforated plastic, typically about 35 mm diameter and 170 mm long, filled with a soil-mix in which seedlings have been grown in a nursery. They are suitable for use on steeper cut slopes with erosion control mat and wire mesh, as the tubes can fit within the openings of the wire mesh. A major limitation is that the planter tube contains a relatively smaller amount of soil-mix than the more traditional method of notch planting (see Table 2.1).

Figure 2.24 Use of Root Tube Planters

2.6 Soil Bioengineering

Site trials have indicated a wide variation in the performance of bioengineering techniques. In common with vegetation establishment generally, planting under bioengineering has fared less well on slopes with thin dry soils.

Bioengineering applications that may be appropriate for some aspects of slope works are listed in Table 2.8. They have not been commonly used in Hong Kong to date, but there have been some trials carried out on man-made slopes (Cheung et al, 2011) and for the restoration of landslide scars (Campbell et al, 2008). Jacobs China Ltd. (2007) notes that "there is limited experience in the application of soil bioengineering measures to any type of man-made soil slopes in Hong Kong and that experience has largely been with natural slopes".

Attempts to quantify the reinforcing capability of plant rooting systems, with regard to their use as a means of improving slope stability, have been reported in various local (Yim et al, 1988) and international literature, and following local site trials (Campbell et al, 2008). However, it is difficult to ensure the lateral spread and depth of a root system within a soil mass in practice.

Table 2.8 Bioengineering Techniques

Technique	Description
Brushlayers	Use of woody cuttings to build live check dams on slopes to prevent development of surface erosion.
Fascines	Bundles of live branches laid in trenches across a slope, usually following the contours of the slope.
Hedgelayers	Live rooted plants installed along constructed benches, laid perpendicular to the slope face with the growing tips directed out of the slope.
Live check dams	Dam structure constructed from live plants and locally available materials to prevent development of surface erosion rills.
Live stakes	Live branches or plant stems cuttings that root readily from cuttings. Usually, all side branches are removed prior to installation.
Palisades	Woody/hardwood cuttings planted across a slope, usually following the contours, to form a barrier to surface water flow.
Vetiver grass *Vetiveria zizanioides* (香根草)	Vetiver grass is a proprietary grass species (i.e. purposely cultivated and marketed under trademark). Plants are sterile and cannot reproduce, but have a very deep rooting system which may allow better uptake of water and nutrients than other species. The long roots may also help enhance slope stability and protect against shallow surface failure or surface erosion, but the beneficial effects are difficult to quantify. The suppliers suggest that if planted in closely spaced rows across a slope, it can form a bioengineering barrier. It has been planted in Hong Kong within planter holes formed on hard slope cover, as illustrated in Figure 2.25. Vetiver grass should be used with caution, as it is a non-native species and can grow very quickly and may require more frequent maintenance. Additionally, it has a relatively sharp leaf blade edge which may be hazardous to pedestrian if planted at the lower part of slopes next to footpath.

(a) Overall view of Vetiver grass used at a shotcreted catchwater cut slope

(b) Close-up of an individual plant

Figure 2.25 Use of Vetiver Grass in Hong Kong

It is more widely accepted that most slope vegetation has some bioengineering effects, providing a measure of protection against surface erosion, especially those species with deeper root systems. The benefit is not uniform in scale or distribution, and is very difficult to quantify. Campbell et al (2008) note that "although the benefits of using vegetation to prevent soil erosion are well established, its ability to stabilise slopes subject to shallow failures is less well proven, and certainly less well quantified". They also note that bioengineering measures should be applied with caution to man-made slopes.

3 Landscape Design Processes

3.1 General

This Chapter outlines the process for landscape design and integration with engineering works, from initial considerations, through to implementation on site and the preparation of Maintenance Manuals (MM).

Figure 3.1 illustrates the typical slope works process, indicating the contributions of different parties by project phase.

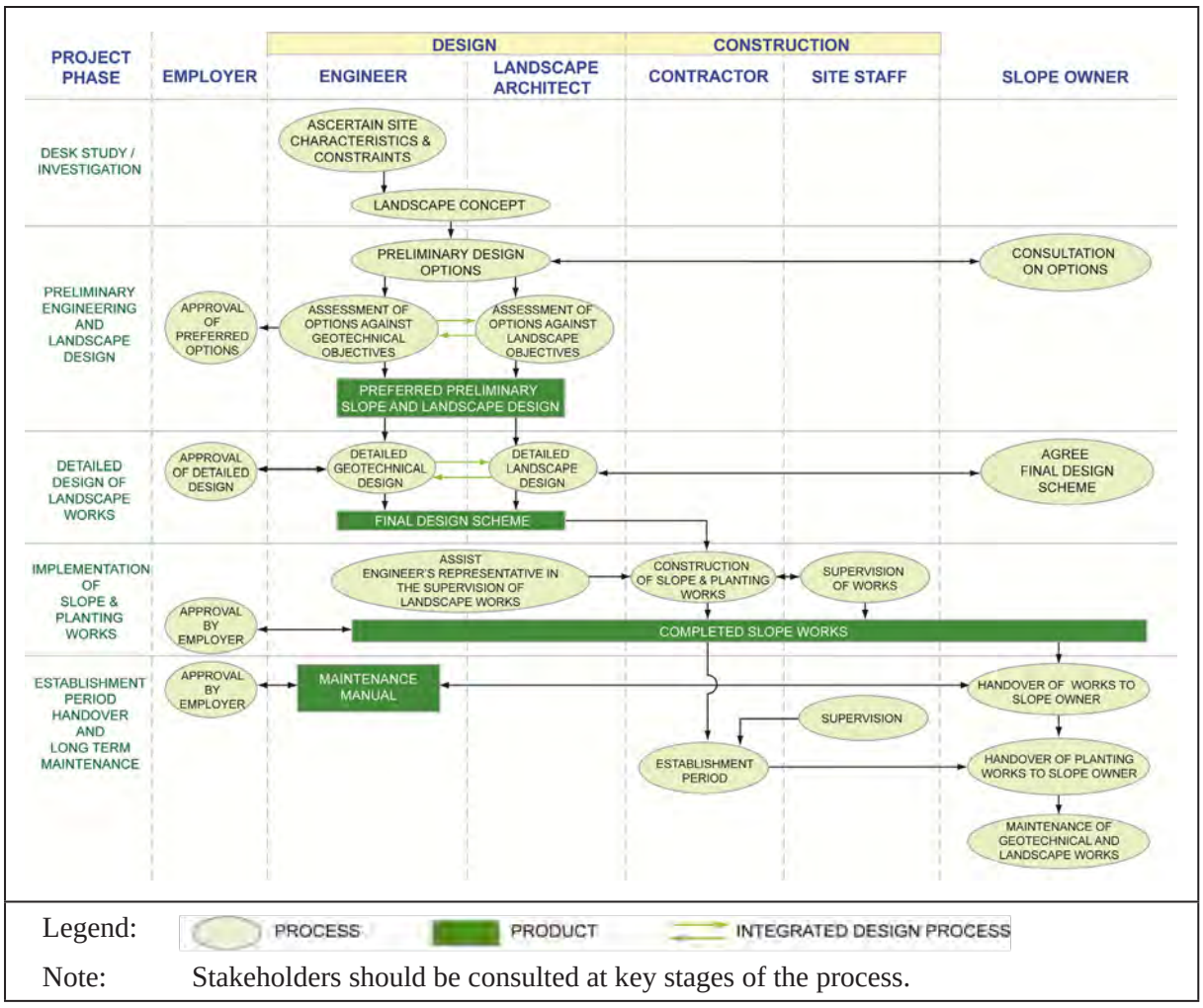


Figure 3.1 Typical Slope Works Process Diagram

3.2 Developing a Landscape Concept

Before any design work is undertaken, designers are encouraged to identify the desired outcome of the completed slope, i.e. to develop a 'landscape concept' based on the overall landscape objectives.

The landscape concept may, for example, be to remove existing hard cover; and to provide vegetation cover in order to integrate the finished slope, visually and environmentally, with its surroundings (e.g. Country Park setting, adjacent woodland, nearby masonry faced slopes or retaining walls). In developing a concept, the design team should start from a perspective of how to provide a soft landscape treatment, where practicable, before considering the use of hard surfaces. This will help to achieve a visually attractive slope appearance and contribute to an overall greener environment.

Where several related slopes are to be formed or upgraded at one time (e.g. slopes along a highway, or at a large-scale site formation project), an area-based integrated approach should be adopted when developing the landscape concept. Successful examples include the landscaping of slopes under the Landslip Preventive Measures (LPM) Programme along South Lantau Road (between Mui Wo and Pui O), and the large-scale themed landscaping of slopes at Penny's Bay around Hong Kong Disneyland.

3.3 Landscape Design Considerations

Public safety is paramount and the landscape design has to be practicable, taking into account the prevailing physical and environmental settings of the site, safety requirements, as well as cost effectiveness and sustainability of the proposed works. Where slopes are located in an environmentally or socially sensitive area, the need for contextual landscape works should be considered. The landscape design should also take into account the anticipated future development in the area to ensure that the design is appropriate, as far as can be judged. The balance of these considerations should be further examined through the option assessment and preliminary design process. Designers are encouraged to use cost effective, simple and sustainable landscape solutions, wherever practicable.

Table 3.1 suggests some of the existing physical and environmental site conditions which may need consideration when developing a landscape design.

Much of the information for the initial development of both engineering and landscape design options can be obtained from examination of existing site records, study of aerial photographs and site observations. More refined information from detailed site inspections, site-specific ground investigations, topographical surveys, tree surveys and possibly ecological surveys can be gathered during the process of developing design options. Appendix D provides a comprehensive list of landscape design considerations.

New slope works to be constructed as part of a large-scale project may be subject to land allocation (lease) conditions, planning requirements and/or the Environmental Impact Assessment Ordinance (EIAO). Where this is the case, details of the measures for protection or enhancement of existing flora and improvement of slope appearance may be required in the landscape proposals.

Minor slope works may be exempted from the EIAO, subject to the advice of the Environmental Protection Department (EPD). Works for upgrading of existing slopes under the Government's Landslip Prevention and Mitigation (LPMit) Programme are commonly exempted. However, for any slope works in sensitive areas, as listed in Item Q1 of the EIAO (e.g. Country Park or special areas, conservation areas, marine parks or marine reserves,

sites of cultural heritage, sites of special scientific interest), a submission should be made to EPD for confirmation that the project can be classified as a non-Designated Project under the EIAO. Otherwise, such works should follow the statutory EIAO procedures.

Table 3.1 Site Considerations

Site Setting	Consideration
Existing physical conditions	• Slope type (i.e. cut, fill, retaining structure, natural terrain). • Surface cover (e.g. vegetation or hard cover). • Likely soil conditions (i.e. soil, rock and weathering grade). • Gradients and orientations of the new or existing slope and its relationship with the adjacent land. • Surface and sub-surface drainage. • Signs of erosion. • Present visual impact.
Environmental aspects	• Identification and condition of existing vegetation, particularly trees, on and around the site. Tree surveys should be conducted to identify mature trees, especially those that are of rare species, or with ecological or amenity value. A review of all vegetation should be undertaken in areas of ecological importance. • Identify trees which may pose a hazard for future risk assessment. • Urban, rural, Country Park, water gathering grounds, etc. • Surrounding elements (e.g. full vegetation, buildings/structures or roads). • Areas within the site shaded by structures or overhanging tree canopies. • Slope areas particularly exposed to sun (i.e. south-facing), or to wind.

3.4 Preliminary Landscape Design

Landscape options should be developed according to the landscape concept, and should address each of the three broad landscape approaches set out in Section 1.4, namely:

(a) Minimise the physical impact of the proposed works.

(b) Landscape softworks, i.e. maximise opportunities for incorporating vegetation into the slope.

(c) Landscape hardworks, i.e. aesthetic treatment of hard surfaces.

Landscape softworks generally achieve a more pleasing slope appearance and hence are preferable, wherever practicable, to landscape hardworks. The possibility of creating a vegetated surface should therefore be fully explored and investigated at the preliminary design stage.

Stakeholders should be consulted during the development of landscape design options, where appropriate. Typically this might include the land owner/client for the works, neighbours and maintenance agent(s). For slopes in visually or environmentally sensitive

locations, this might additionally include special interest groups. There may be conflicting views about the landscape concept to be adopted. Some compromises may be necessary.

Landscape options should be developed for each of the proposed engineering design options. Engineers should work with landscape architects during preliminary design stage to develop innovative engineering solutions that can promote enhanced landscaping solutions, or provide added value.

In assessing cost effectiveness, designers should consider carrying out a life-cycle cost analysis of all landscape options to ensure a balance between capital costs, recurrent maintenance costs and long-term sustainability. This is especially important where the completed landscape works have a limited design life and may need to be periodically replaced (e.g. options involving some of the mulching systems). The concept of life-cycle cost is discussed in Section 2.2 in Chapter 4 of the *Project Administration Handbook for Civil Engineering Works* (HKSARG, 2010).

The rationale for selection of the preferred engineering and landscape design option, including any suggestions made by option reviewers, slope owners or other stakeholders, should be formally documented as a design brief to guide subsequent development of the detailed design.

3.5 Detailed Design of Landscape Works

3.5.1 General

Once a preliminary design option has been agreed, engineering and landscape designs can be developed to a detailed level. This will require an integrated approach, involving a joint effort of engineers and landscape architects, to produce a landscape design which meets the intended landscape concept and objectives (see Figure 3.1). The design team may need to carry out periodic reviews to ensure that all necessary requirements are met. The corresponding design considerations should be documented in the design report. For the benefit of the Contractor and supervision personnel, the landscape objectives of the proposed works should be clearly stated in the contract documents.

Figure 3.2 illustrates sites where different engineering/landscape options to parts of the slopes have not been well integrated. This highlights the importance of taking the site context into consideration, i.e. a holistic approach that considers the overall unity and coherence of the final landscape design.

If the detailed landscape design differs significantly from that presented in earlier option assessment, further review and consultation may be necessary.

Designers should also ensure that there are no conflicts between the engineering and landscaping design, e.g. soil nail heads or drainage channels do not conflict with existing tree locations.

To assist in detailed design, recommendations on application of landscape softworks and hardworks for various types of man-made slopes are presented in Chapter 4. Landscape

treatments for natural terrain mitigation measures and landslide repairs are given in Chapter 5 and Chapter 6 respectively.

Figure 3.2 Examples of Poorly Integrated Landscape Works

3.5.2 Detailed Design of Landscape Softworks

The objectives of landscape softworks are to create a sustainable vegetation cover that will be compatible with the surrounding area, both visually and ecologically, and to provide opportunities for the development of ecological habitats. Planting designs to meet these objectives should be based on a detailed understanding of the existing conditions of the site, which include the following:

(a) underlying soil, including its depth and/or volume, chemical and physical properties,

(b) groundwater conditions and availability of artificial water supply,

(c) surface and sub-surface drainage conditions,

(d) existing vegetation on, or around, the slope including its condition, health and ecological value,

(e) environmental conditions (e.g. shading, exposure), and

(f) adjacent land use.

Different types of planting that can be applied to slopes are described in Section 2.3.2. Designers should select the type of planting and then select individual plant species based on their understanding of the condition of the site, the degree to which the elements required for successful establishment and growth of plants are available (i.e. soil, water, air and sunlight), together with the overall life-cycle cost. Grass cover provided for initial erosion control of a

newly formed slope may not be sustainable in the long term. The dispersal and invasion of vegetation from adjacent natural terrain will help to improve the ecological conditions with time, although the process may be slow.

The designer should avoid planting of vegetation that may be in conflict with the engineering works, or the functional aspects of neighbouring land uses. Examples include plants blocking vehicle sightlines and tree roots affecting underground utilities.

The extent and nature of the landscape application, together with details of erosion control measures, should be clearly shown on landscape works drawings and in any accompanying contract documents. These should indicate the following:

(a) different plant species by plant type (Appendix F provides a suggested list),

(b) size of the plant specimen to be used (e.g. seedling or small size tree),

(c) percentage of each species,

(d) mix - arranged randomly or in patterns, individually or in small groups,

(e) spacing and layout (e.g. square or staggered),

(f) number of plants calculated from the spacing and the surface area to be covered, and

(g) types, extent and locations of erosion control measures.

Ecological planting should be kept natural and simple, and native species should be planted as far as possible. However, localised planting of fast growing pioneer tree species, which establish quickly and help create a sheltered micro-climate to promote the development of slower growing native species, may also be considered. Further advice on the use of pioneer species is given in Section 8.2.2.

Landscape softworks and hardworks should comply with requirements stipulated in the GS, in which details of materials and workmanship for most landscaping works are provided. The designer should check the adequacy and appropriateness of relevant clauses in the GS for their planting design. All necessary additions or amendments should be provided in the PS.

Proprietary planting products, materials and techniques are not covered by the GS (or Standard Methods of Measurement) and would need to be dealt with in the PS. The descriptions of the products should be sufficiently general in nature to allow choice from a range of possible proprietary products.

Reference may be made to Section 26 of the GS and DEVB (2010c) for works to protect existing trees. The extent of tree protection works must be clearly shown on the contract drawings. Specialist input from an arborist may be required in determining the need

for any temporary supports or structures to allow trees to be retained on site. Where these are in the form of stakes, ties and guys, reference may be made to Clause 3.36 of the GS. Large-scale rigid steel support structures, if required, may need to be specially designed to cater for the tree and site conditions, and the potential effects of wind loading.

The extent, form and duration of any tree supports should be clearly set out in the contract documents. Also, if they are to be left in place after the contract, prior agreement should be obtained from the slope owner.

The possible scope and scale of landscape maintenance operations should be considered during the design process. The requirement of a periodic watering operation should be avoided by the choice of appropriate vegetation species, although such action may be necessary for some ornamental planting. Further advice on the maintenance of landscape works is given in Chapter 8.

3.5.3 Detailed Design of Landscape Hardworks

The key objective of landscape hardworks is the aesthetic treatment of hard surfaces and any other hard elements, such as engineering works and slope furniture, in order to make them as visually acceptable as possible. In combination with landscape softworks, the overall appearance of hard surfaces and elements could be further improved.

Different types of aesthetic treatments are described in Section 2.4, which can be applied to hard slope covers, exposed surfaces of the slope elements and slope furniture. Simple and suitable planting to complement the special hard landscape finishes should be provided where possible.

Designers should select the type of aesthetic treatment for the individual hard elements with reference to the following criteria:

(a) degree to which the treatment is effective in meeting the landscape objectives,

(b) ease of construction, in particular, co-ordination with the engineering works,

(c) life-cycle cost,

(d) durability/long-term performance,

(e) ease of maintenance and replaceability, and

(f) sustainability (i.e. treatments should be site-specific and favour the use of locally available materials).

Aesthetic treatments should be considered within the whole context of the slope and not in isolation. Where there are a number of elements that might be treated, designers

should seek to create a co-ordinated approach to achieve a unified overall slope appearance (see Figure 3.2).

Designers should ensure that treatments are properly co-ordinated with all aspects of the engineering works, and there is no conflict such that the quality of the intended finish can be fully realised on site. For new retaining walls associated with public highways, the designer should consider whether the advice of ACABAS should be sought. Similar to engineering works, on site validation of landscape design considerations by the designer is needed.

Specifications for common landscape hardworks materials and finishes (e.g. basic concrete works, or painting of metalwork) are provided in the GS. Where special finishes, such as those shown in Figure 3.3 are proposed and agreed by the slope owner, specific requirements should be stated in the PS.

(a) Coloured and textured concrete panels applied to a piled retaining wall

(b) Artificial rockwork and masonry applied to a concrete retaining wall

Figure 3.3 Special Finishes for Landscape Hardworks

Designers should identify any special procedure to be undertaken by the Contractor for landscape hardworks, e.g. submission of material samples and method statements, construction of trial panels, levels of workmanship, more demanding tolerances and allowance for inspections by designers.

Applications with an artistic or graphic design content (e.g. artificial rockwork, graphic patterns in concrete finishes or painted images) will need specific design drawings to be prepared by the landscape architect for inclusion in the contract. The requirements for any 'art direction' of such finishes by the landscape architect during the construction stage should also be considered.

3.6 Maintenance Manuals

The provision of as-built records and a MM is the final part of the design process, wherein the long-term maintenance requirements of the landscape works should be clearly set out.

While guidance on slope maintenance is given in *Geoguide 5 - Guide to Slope Maintenance* (GEO, 2003a), the requirements of landscape works may not be specifically addressed. For landscape softworks and hardworks, the MM should include:

(a) A description of the landscape objectives and overall design intent for the slope.

(b) As-built records of both landscape softworks and hardworks.

(c) Photographic records of the finished landscape at the time of handover to the slope owner.

(d) Requirements to monitor tree health and conduct tree risk assessments, including notes on the frequency of such inspections, and the recommended personnel to undertake them.

(e) Recommendations for future maintenance of the planting (e.g. thinning out of particular species, removal of an invasive species, items which will be required for long-term survival of landscape softworks applied to inert hard surfaces and the intention to allow natural dispersal of plant species from the adjacent landscape).

(f) If there are old and valuable trees (e.g. trees on old masonry walls), these should be brought to the attention of the slope owner, so that necessary tree management and maintenance operations can be arranged.

(g) Particular maintenance needs for ornamental planting, if applicable.

Suggestions for landscape items to be included in the MM, together with inspection sheets for landscape softworks, are given in Appendix H.

4 Landscape Treatment for Man-made Slopes

4.1 General

This Chapter provides guidance on landscape treatment for engineering measures implemented on various types of man-made slopes. The guidance takes account of common constraints and opportunities, and outlines some basic design considerations and approaches for landscape treatment. The advice should not be used prescriptively, and designers should seek the most appropriate solution that will meet the specific requirements and conditions of an individual slope. Where a number of slopes are being considered within the same geographical location, a consistent approach to their landscape treatment is recommended.

Landscape works to existing man-made slopes may be carried out along with the slope upgrading or preventive maintenance works, but they can also be landscape improvements in their own right. The choice of landscape treatment will depend on the existing slope conditions, environmental setting and site-specific considerations as discussed in Section 3.3. The design of landscape works should account for the proposed engineering and slope furniture elements (e.g. hard cover, maintenance stairways, handrailings), together with existing elements if retained.

Where the design objective is to replace the existing hard surface cover with a vegetation cover, the reasons for covering the slope with hard surface should be reviewed. This is to ensure that potential instability factors will have been accounted for in both the engineering and landscape designs. Also, the risk of small-scale failure needs to be considered and balanced against the visual and ecological benefits of the replacement with a vegetation cover. The designer should inspect the exposed slope surface after the removal of hard cover to review the design assumptions made with regard to this balanced assessment.

New slopes by their nature (i.e. unconstrained by existing engineering or slope furniture elements) provide more opportunity for landscape softworks, thus allowing more integration with their surroundings. However, the gradient of new slopes may be influenced by adjacent structures, lot boundaries or other land matters which may restrict the choice of landscape treatment. In general, opportunities for landscape softworks reduce as slope gradient increases.

The condition of existing trees and other plants within or in the vicinity of the site should be assessed to determine their value and the need for protection. Good practice for tree protection works and excavation in the vicinity of trees is given in Section 7.2.

4.2 Cut Slopes

In general, new cut slopes in soil, rock or combination of both are formed as part of site formation works, whereas existing cut slopes may require upgrading or preventive maintenance works.

4.2.1 Soil Cut Slopes

Soil cut slopes are generally formed or upgraded by one, or a combination, of the following methods:

(a) Cutting back to a flatter slope.

(b) Soil nailing.

Soil Cut Slopes Formed or Upgraded by Cutting Back

In designing an unsupported new soil cut slope, the appropriate slope gradient to be formed will largely depend on material type, stability considerations, topography and the existing landscape, but will generally be less than 40°. Typically the flatter the formed cut slope, the greater the opportunities for planting. Consideration should be given to the profile of the surrounding topographical pattern with a view to achieving a smooth transition with the adjoining terrain, as illustrated in Figure 2.4.

Forming a new cut slope, or cutting back an existing slope, will result in loss of almost all trees within the footprint of the completed slope. In some cases, there may be opportunities to retain existing trees by constructing retaining structures around them, as illustrated in Figure 2.1.

Examples of slope engineering elements and slope furniture on cut slopes, which may require landscape hardworks, include:

(a) Concrete surfaces, which might be needed for soil cut slopes steeper than 55°, and other concrete elements (e.g. catchpits, planter walls, access stairways). Guidance on treatment of these is given in Section 2.4.1.

(b) Metalwork elements (e.g. handrailings, metal access ladders). Guidance on the treatment of these is given in Section 2.4.2.

Section 2.3.2 outlines the design considerations in the selection of planting techniques and types. Ecological planting should be adopted where practicable. In small-scale urban situations where high quality of visual appearance is desired, ornamental planting may be considered if the required maintenance commitments have been agreed.

Figure 2.15 and Table 2.2 provide general guidance on types of planting and erosion control measures that would be appropriate for different slope gradients. Designers should consider the potential effect of erosion control matting and wire mesh on the proposed planting works (see Sections 2.3.7 and 2.3.8).

Where hard surfacing is necessary on steep cut slopes, opportunities for planting of vegetation should be explored, with a view to minimising visual impact. Examples are:

(a) Toe, crest and/or berm planters to allow planting of climbers

and groundcover species (see Section 2.3.6). This is very much the preferred approach if space is available.

(b) Core hole planting (see Section 2.3.6).

(c) Proprietary mulching systems (see Section 2.5.1) and other proprietary systems (see Section 2.5.2).

Soil Cut Slopes Upgraded by Soil Nailing

Where site clearance is needed to facilitate the construction of soil nails, the operation should be carried out with caution in order to minimise the damage to existing vegetation. Site clearance generally includes cutting of surface vegetation only, without removal of the associated roots. Also, cutting or pruning of woody shrubs and trees should be avoided where practicable. The extent of site clearance works should be limited to areas that are required by the engineering works.

Several types of existing vegetation, especially grass and groundcover plants, will regenerate after the clearance operation. Figure 4.1a illustrates a case where a grass and shrub mix was applied to the slope after completion of site clearance and the subsequent slope works. Figure 4.1b shows the same slope two years later, where the pre-existing ferns which were cut back by site clearance works have re-established.

(a) Grass hydroseeded slope shortly after completion of works

(b) Natural regeneration of existing ferns (within 2 years)

Figure 4.1 Natural Regeneration of Existing Vegetation

In order to avoid damage to existing trees, the soil nails need to be located away from tree roots where practicable. After exposure of the surface rooting system, following site clearance, adjustment of soil nail locations on site should be made to achieve this.

Soil nail heads should be recessed into the slope face where practicable (see Section 2.2.5). This allows soil-mix to be placed on top of soil nail heads, which provides opportunity for planting of climbers and groundcover plants.

Soil nail heads exposed on a slope surface may be considered for landscape hardworks, guidance on which is given in Section 2.4.1. Positioning of soil nail heads in regular pattern can help to reduce the visual impact (see Figure 2.10). Alternatively, soil nails heads can be made less visually intrusive in the form of a decorative pattern, or encased in a concrete grillage structure or a concrete skin wall.

4.2.2 Existing Rock Cut Slopes

Existing rock cut slopes are typically upgraded by Rock Slope Stabilisation Measures (RSSM), as described in the *Geotechnical Manual for Slopes* (GCO, 1984). Preserving landscape features on existing rock slopes may comprise measures to protect vegetation on the face, or immediately around the edge of the slope.

Visible elements of RSSM which may be considered for landscape hardworks include:

(a) Concrete surfaces, which may be in the form of sprayed concrete applied to highly fractured or more weathered zones of the rock face, or in the form of concrete buttresses. Guidance on possible treatment is given in Section 2.4.1. Figure 2.9 also provides guidance on the shape and form of new concrete buttresses.

(b) Wire mesh which may be attached to the slope face, particularly where the face is heavily jointed or likely to unravel. Guidance on possible treatment is given in Section 2.4.2.

Opportunities for planting are likely to be limited on existing rock slopes, unless new planters are provided for screen planting (e.g. planting of climbers and trailing plants to improve the slope appearance). Wire mesh may serve as a supporting trellis to promote the growth of climbers and trailing plants, as shown in Figure 4.2.

The rehabilitation of quarry slopes, including landscape treatment has been undertaken since the late 1980s and there is extensive literature available on the technical details. Design considerations adopted in these quarry rehabilitation project to improve the landscape and ecological conditions of a quarry site may be relevant to rock slope works, as follows:

(a) Climbers growing down the wire mesh on a steep rock slope

(b) Close-up of climbers on wire mesh

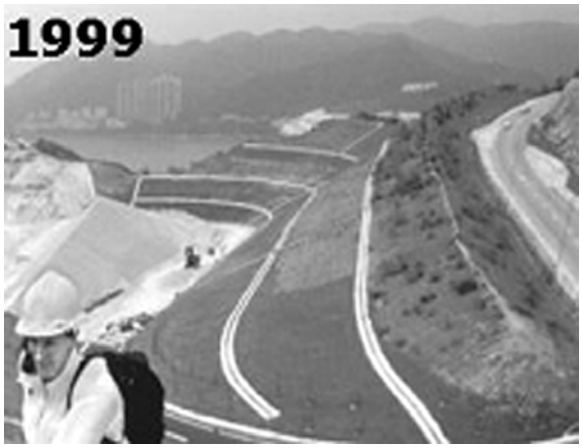
Figure 4.2 Wire Mesh Acting as a Trellis for Climbers on Rock Slopes

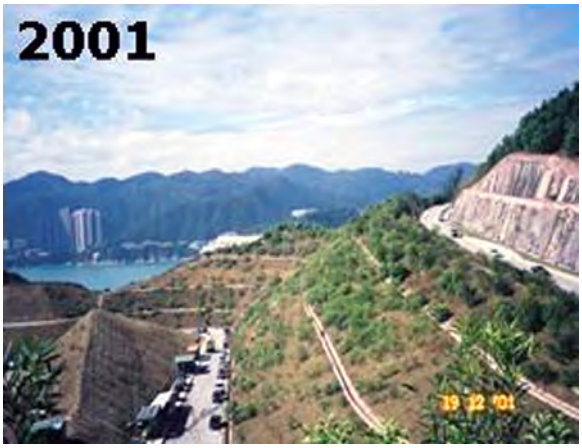
(a) Creating a gentle slope profile that can support planting of vegetation. The rehabilitated Shek O Quarry provides an example where the prevailing steep slopes were largely overfilled to form a gentle profile to support a vegetated landscape (see Figure 4.3).

(b) Creating nesting niches in rock slopes at rural areas for particular bird species. Rehabilitated rock faces have included nesting niches for some local bird species, such as Black-eared Kites (*Milvus migrans lineatus*) and Peregrine Falcons (*Falco peregrinus*), as illustrated in Figure 4.4.

(c) Creating a more natural drainage channel, if excavation in a natural watercourse is required (see Figure 4.5). A similar detail was used at Shek O Quarry, where channels were dug into bedrock to provide a more natural appearance.

In recent years, several old rock borrow areas have been upgraded. The engineering options to stabilise these typically comprise RSSM. Where space permits, provision of a buffer zone and/or a barrier near the slope toe may be an alternative approach. As such, the existing rock faces and the vegetation on slope have been left largely untouched. An example of protective mitigation measures and the associated landscape works applied to one of these old rock borrow areas is illustrated in Figure 4.6. In this particular example, artificial water ponds were created to serve as habitats for Romer's Tree Frogs, a protected species known to use the site below the rock slope as a breeding area.





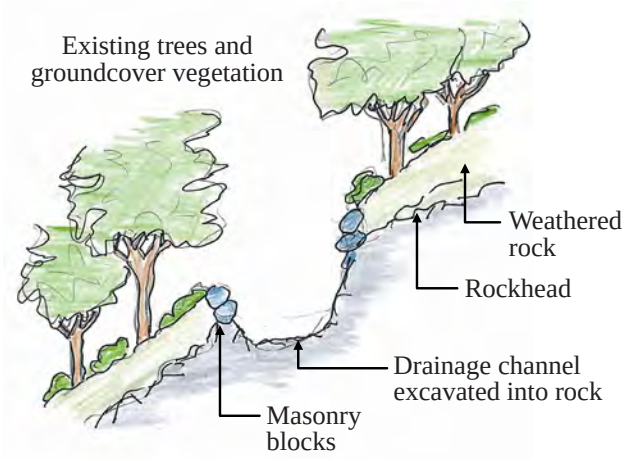
Note: Progressive improvement in the landscaped appearance over a 5 year period

Figure 4.3 Re-profiled Rock Slopes and Planting at Former Shek O Quarry

(a) Niches in a former quarry rock slope at Sok Kwu Wan

(b) Close-up of a nesting niche for Peregrine Falcon at Shek O Quarry

Figure 4.4 Provision of Nesting Niches on Rock Slopes in Rural Area



(a) Typical detail of a 'natural' drainage channel

(b) Example of a similar detail, Shek O Quarry

Figure 4.5 Use of 'Natural' Drainage Channels

Artificial breeding ponds with shrubs and groundcover planting

Climbers and hanging plants on gabions

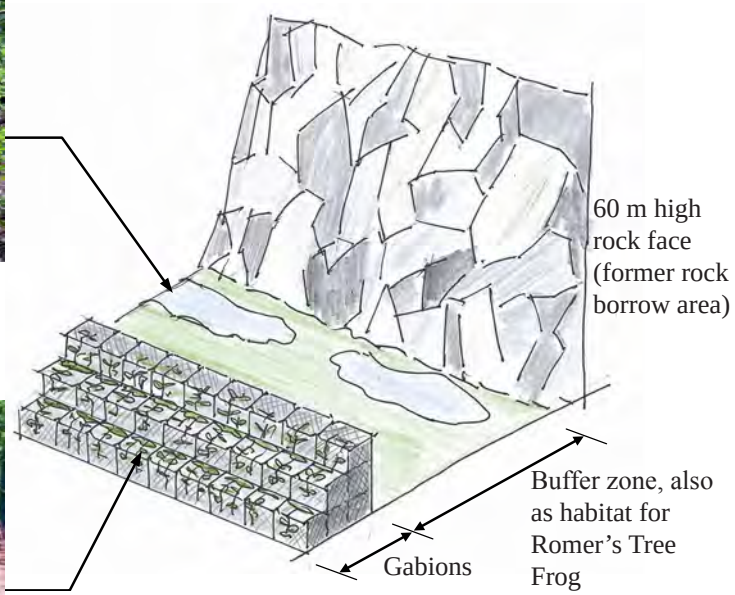


Figure 4.6 Mitigation Measures to Old Rock Borrow Area

4.2.3 New Rock Cut Slopes

In the formation of new rock slopes, attention should be given to possible impact of the works on the existing landscape, both on the slope and in the adjoining areas (see Section 2.2.1). Measures should be taken to protect existing vegetation, including the control of dust generated from rock excavation.

New rock cut slopes will usually be formed at steep angles, which will limit the overall 'footprint' of the slope and extent of disturbance to the existing landscape. However, opportunities for planting will also be reduced. Scope exists to adjust the height of slope batters, the slope angle and width of the berms to create opportunities for improving the final appearance of a rock slope.

New rock cut slopes may be left as a bare rock surface where found to be stable. Where the ground conditions are unfavourable and RSSM are needed to stabilise the rock face, landscape hardworks for the visible elements of RSSM should be considered. The guidance as provided for existing rock slopes in Section 4.2.2 is applicable. Similar to existing rock cut slopes, planting opportunities typically comprise the use of toe and berm planters to support the growth of climbers and trailing plants. If the planters are large enough, shrubs and small trees may also be planted.

Where land constraints permit, wider berms (i.e. >3 m in width) may be provided to accommodate planters capable of supporting trees and large shrubs, as well as climbers and groundcover plants. These will increase the greening effect and allow for the development of a more diverse ecological habitat. This approach was used extensively on the approach roads to Tsing Ma Bridge (Figure 4.7). The *Highway Slope Manual* (GEO, 2000b) suggests that for new rock cut slopes, provision of berms with sufficient width to accommodate planting works should be considered.

(a) Overall view of rock slope with berm planters

(b) Close-up of berm planters

Figure 4.7 Planters on Berms of a Rock Slope

4.3 Fill Slopes

4.3.1 Existing Soil Fill Slopes

Existing fill slopes may be upgraded using the following methods:

(a) Excavation, typically to a depth of 3 m, and replacement with compacted soil, soil cement mix, rockfill or no-fines concrete. The excavation may be either in bulk, or by a pit-by-pit approach.

(b) Installation of soil nails and construction of grillage structure.

Fill Slopes Upgraded by Re-compaction

Where slopes are upgraded by excavation and re-compaction of fill materials, almost all existing trees and vegetation on the slope will have to be removed. However, the upgraded slope will usually be less than 35°, thus offering a good opportunity for planting.

Excavation and replacement of loose fill around existing trees may be better carried out by a pit-by-pit approach, particularly where access for excavation and/or compaction equipment is limited. Where the fill is replaced by material other than soil, designers should ensure that sufficient depth of soil-mix (see Table 2.3) has been provided on the top of the replacement materials for planting of vegetation. Where a soil cement mix comprising around 2% to 5% cement has been used as a replacement material, trials have revealed that vegetation could be successfully established on the slope surface (Fugro, 2009). Measures to protect existing trees are given in Section 7.2.

Fill Slopes Upgraded by Soil Nails

Soil nailing in conjunction with a concrete grillage system is an increasingly common method for upgrading of existing fill slopes. The grillage system, which interconnects the soil nail heads, typically covers about 50% of the slope area (HKIE, 2003).

In order to avoid damage to existing trees, the soil nails and individual grillage members should be located away from trees and the associated roots, as far as practicable. On site adjustment of soil nail locations and alignments of grillage members may be necessary to achieve this, once the position of surface tree roots are exposed following the site clearance. Figure 4.8 shows a typical arrangement of soil nail grillage around an existing tree.

The grillage system will usually be constructed partially below the existing slope surface. The visible surfaces of the concrete grillage may be considered for landscape hardworks, guidance for which is given in Section 2.4.1. Figure 4.9a shows an example of a grillage structure that has been coloured to soften its appearance. The overall appearance of the slope has further improved with time (see Figure 4.9b), as woodland vegetation takes over the slope from the initial hydroseeding mix.

Where the top of the grillage system is constructed above ground level, the cells between grillage members can be filled with a soil-mix to provide areas for planting of grass, shrubs and/or other groundcover species. More substantial planting may be possible for cell areas with gradient less than 35°, as plant canopies will help to screen the grillage structure below. For slopes with steeper angles, cement may be added to the soil-mix to increase the mass strength of the fill material with a view to reducing the potential for slumping.

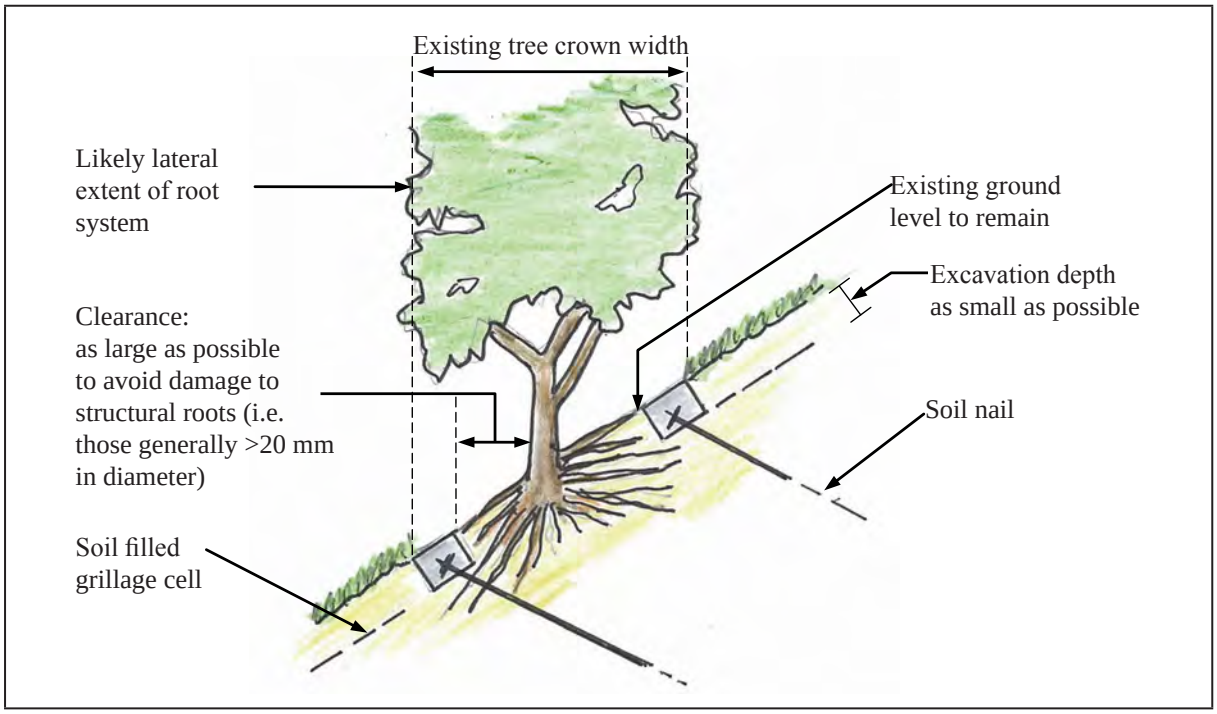


Figure 4.8 Soil Nail Grillage in Vicinity of Existing Tree Roots

(a) Exposed grillage painted to reduce the initial visual impact of the concrete

(b) The same slope 2 years after completion of planting works

Figure 4.9 Landscape Treatment of Concrete Grillage for Soil Nailed Fill Slope

Where the slope gradient permits, the grillage may be recessed into the slope and an overlay of soil-mix can be applied for planting of vegetation. Figure 4.10a shows a view of a slope immediately after placement of the overlay soil-mix, and Figure 4.10b shows the same slope after the successful establishment of grass cover.

(a) Immediately after backfilling over concrete grillage

(b) Vegetation established over recessed concrete grillage

Figure 4.10 Use of Buried Concrete Grillage for Fill Slopes

For steeper fill slopes, a grillage system with the incorporation of upstands to form terraces may be considered, as shown in Figure 4.11. Spaces within the terraces can be filled with soil-mix for planting of groundcover plants and shrubs, and may include small trees if space permits.

4.3.2 New Soil Fill Slopes

The formation of new soil fill slopes may require existing vegetation to be cleared. Attention should be given to limiting the extent of clearance, as far as practicable.

The gradient of new fill slopes will generally be less than 35°, which offers a good opportunity for planting of shrubs and small trees. If the fill material is stiff, planting pits should be as large as practicable for the growth of rooting system. Roots of trees and shrubs may help to enhance the resistance of the soil-mix within planting pits against surface erosion.

Where biodegradable erosion control matting is needed, openings will need to be formed locally to allow for the growth of trees and shrubs.

(a) 60 m high landslide below Bowen Road

(b) Cross-section showing the slope upgrading and landscape design

(c) Upgrading works completed and landscape works progressing (June 2011)

Figure 4.11 Terraced Upstands to Facilitate Placement of Soil-mix and Planting

4.3.3 New Rockfill Slopes

The choice of landscape treatment for rockfill slopes will largely depend on the slope gradient. For rockfill slopes up to about 40º, the surfaces could be overlaid with soil-mix, or soil cement mix, for planting of grass and groundcover plants (see Section 2.3.3). The use of a geotextile to prevent migration of soil-mix into the rockfill below needs careful consideration, as it may act as a plane of weakness causing slumping of the overlying soil-mix

layer. A concrete toe structure is usually required to prevent the movement of rockfill down slope. This structure should be as small as is necessary, so as not to be visually intrusive. Landscape hardworks treatment to it may need to be considered.

Pits may be formed within the rockfill for planting of small trees and shrubs, which should be large enough to accommodate the future growth of rooting system. A layer of geotextile can be provided surrounding the pit to prevent the loss of soil-mix into the rockfill. However, the geotextile layer should be limited in extent to prevent it from forming a potential plane of weakness.

Rockfill slopes steeper than 45° may be better left as a rock surface. It is likely that over time vegetation from adjacent areas may disperse naturally onto the slope and establish in gaps between the rockfill.

As with other slope types, planters (see Section 2.3.6) can be considered for climbers and trailing plants to grow over the rockfill surface.

4.3.4 Reinforced Fill Slopes

Reinforced fill slopes are usually formed at steep gradients, thereby minimising the extent of vegetation to be cleared. The engineering of these fill slopes involves the installation of horizontal reinforcing layers (e.g. plastic geogrid or steel reinforcement) to improve the overall stability of the fill mass.

Figure 4.12 Reinforced Fill Slope with Vegetated Surface

The reinforcing layers can be wrapped around at the slope surface to provide additional erosion resistance to the surface material. Hard surfaces may not be required for reinforced fill slopes, thus allowing grass and climbers to be planted on the slope face. Guidance on aesthetics and landscape works of reinforced fill slopes is provided in Chapter 9 of *Geoguide 6 - Guide to Reinforced Fill Structure and Slope Design* (GEO, 2002). Figure 4.12 shows an example of a vegetated reinforced fill slope.

Alternatively, concrete facing panels supported by the slope reinforcing elements can be provided to form terraces for planting of climbers and small shrubs. In this regard, they are similar to reinforced earth retaining structures as described in Section 4.4.4.

4.4 Retaining Walls

4.4.1 General

The use of retaining walls can help to minimise the overall footprint of a slope, reducing the extent of vegetation to be cleared and the overall environmental impact.

Landscape treatment for existing retaining walls will depend largely on the type of upgrading measures adopted and the availability of space for screen planting. There should be a wider choice of landscape treatment for new retaining walls, and provisions for improving the appearance and increasing opportunity for planting could be allowed for during design.

Engineering measures for upgrading of existing retaining walls will usually comprise one, or a combination, of the following:

(a) soil nailing,

(b) adding a concrete skin, or buttressing in front of the wall,

(c) adding concrete at the back of the wall, and

(d) underpinning and/or extending the wall toe.

For large-scale projects, a unified design of surface finish may be adopted for all retaining structures, an example of which is shown in Figure 4.13.

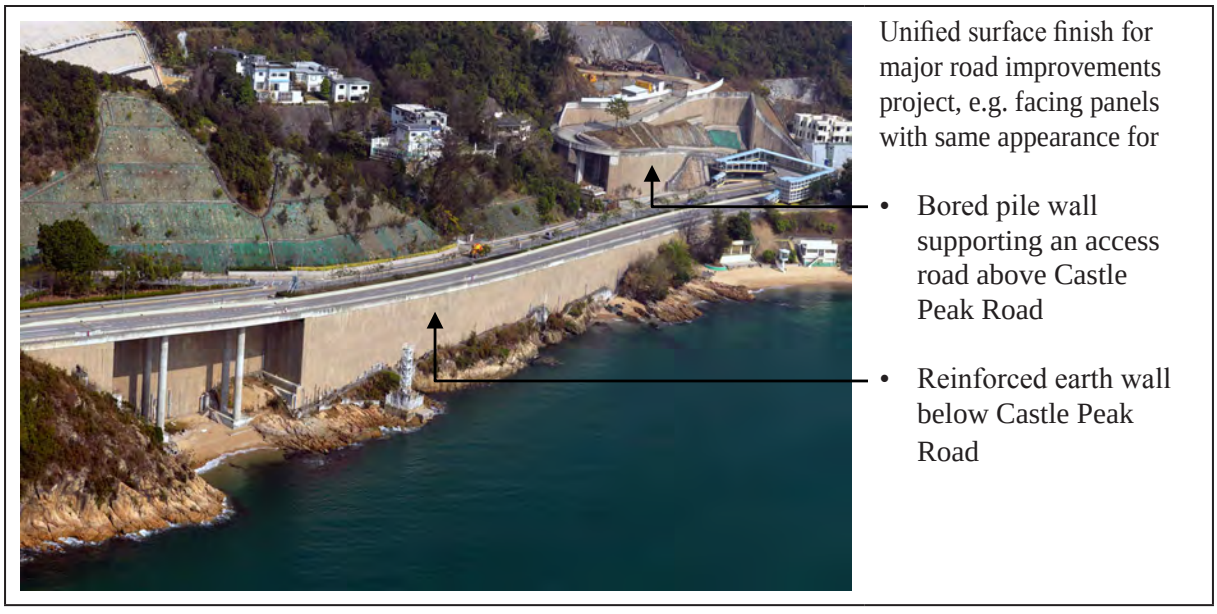


Figure 4.13 Aerial View of Unified Finish for Retaining Walls

4.4.2 Existing Masonry Walls

In designing the upgrading works for existing masonry walls, the appearance of masonry surfacing should be retained where practicable. Consideration should be given to engineering measures that would cause least disturbance to the existing masonry blockwork. Where soil nailing is used to improve the stability of a masonry wall, localised masonry blocks could be removed to allow for the construction of soil nails. Soil nail heads can then be recessed within the wall to reduce their visual impact. Also, the surface finish can be painted in a colour similar to the adjacent masonry blocks in order to maintain the coherence of the finished wall (see Figure 4.14a).

Some existing walls, particularly old masonry walls, may have trees growing on them. For these cases, engineering works should be carefully designed to avoid causing damage to the trees. For example, the locations of nail heads may need to be adjusted on site in order to avoid surface roots. If a concrete skin is to be constructed, openings of adequate size will need to be left in the new facing to accommodate the surface tree roots. Construction of buttresses, underpinning or adding concrete to the back of a wall will require careful excavation in order to avoid damage to trees and their rooting system. Figure 4.14b illustrates wall improvement works around existing trees.

(a) Soil nail heads located beneath masonry blocks of an existing retaining wall

(b) Improvement works around existing wall trees

Figure 4.14 Masonry Retaining Walls with Existing Trees

Wall trees may have a destabilising effect on the wall. Approaches for assessing the possible effect and recommendations on tree protection works and wall stabilisation measures are given in Wong & Jim (2011).

As noted in Section 2.3.6, and if space allows, provision of toe and/or crest planters would provide opportunities for the planting of climbers and trailing plants to improve the appearance of the masonry wall. Also, provision of planting strips above and below the wall would facilitate the growth of tree roots, which can improve overall tree stability (see Section 2.2.3).

4.4.3 Reinforced Concrete Walls

Reinforced concrete retaining walls, particularly cantilever walls, are effective engineering measures to minimise impact on existing trees and other vegetation because of their limited plan extent. Their specific form and configuration can be adjusted locally to avoid disturbance to specific landscape features. Figure 4.15 provides guidance on measures that can be taken to reduce the scale and visual impact of retaining walls. Coping elements, if present, should be carefully designed to articulate and give proportion to the appearance of a wall. Particular attention should also be given to locations of drainage features (e.g. down pipes), slope furniture and any surface mounted elements in order to minimise their visual impact.

The visible surface of a new retaining wall should be considered for application of landscape hardworks (see Section 2.4.1). Figure 4.16a gives an example of a surface finish for a reinforced concrete retaining wall, using pre-cast panels.

Opportunities for planting may involve provision of the toe/crest planters to support the growth of climbers and trailing plants on the wall surface (see Figures 4.15 and 4.16b). Figure 2.18 illustrates examples of walls where plants have been established in the area between the rear face of the wall and a set back drainage channel.

4.4.4 Reinforced Earth Retaining Structures

The construction of reinforced earth retaining structures is similar to that of reinforced soil fill slopes (see Section 4.3.4), but have concrete panels supported by reinforcing elements. These panels can be arranged as an entire vertical wall, or can be stepped back in a terraced arrangement. Where terraces are formed, they can be filled with soil-mix for planting of climbers and groundcover plants (see Figure 4.17b). Similar to other types of retaining walls, planters at the toe and crest should be provided where practicable.

The surface of the concrete panels should be considered for landscape hardworks. A wide variety of patterns, textures and colours to be featured in concrete panels can be considered, an example of which is shown in Figure 4.17a. Guidance on possible treatment is given in Section 2.4.1 and Geoguide 6 (GEO, 2002). Treatment of associated handrailings and metal access stairways should also be considered (see Section 2.4.2).

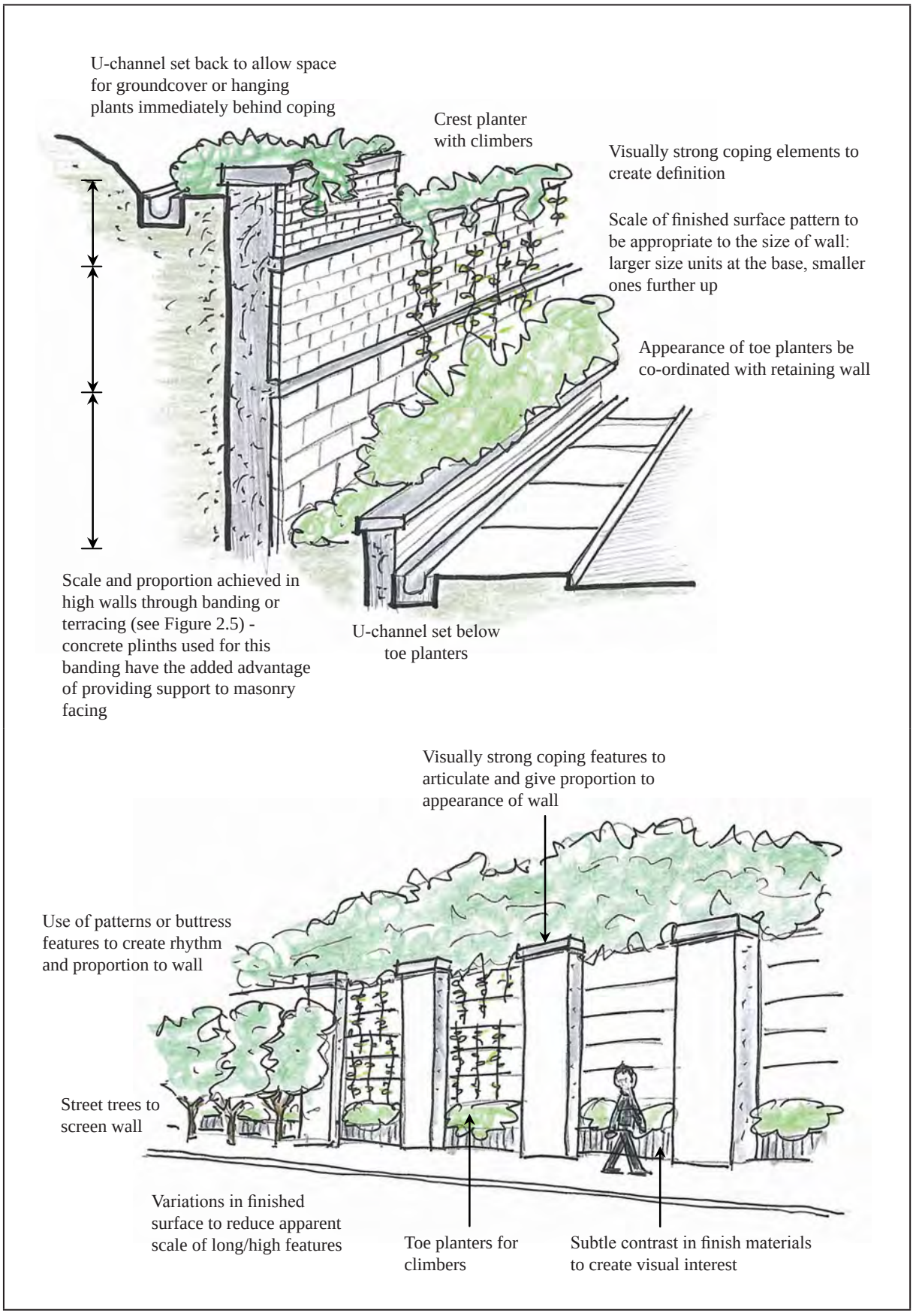


Figure 4.15 Visual Treatment of Concrete Retaining Walls

(a) Stone facing panel to piled retaining wall

(b) Climbers in the toe planter growing up a retaining wall

Figure 4.16 Aesthetic Treatment for Retaining Walls

(a) Reinforced earth retaining structure

(b) Terraced reinforced fill structure with vegetation established on terraces

Figure 4.17 Aesthetic Treatment for Reinforced Earth Retaining Structures

5 Landscape Treatment for Natural Terrain Landslide Mitigation Measures

5.1 General

This Chapter provides guidance on landscape treatment for natural terrain landslide mitigation measures.

About 60% of Hong Kong's land area consists of relatively steep natural terrain. Landslides on natural terrain can be of substantial volume and may have long runout distances, posing potential hazards to facilities below. Landslide hazards on natural hillsides can be mitigated by the implementation of engineering measures which are likely to vary for different types of hazards, namely:

(a) open hillslope failure hazards,

(b) channelised debris flow hazards, and

(c) rockfall and boulder fall hazards.

There is an increased emphasis on the need for landscape treatment of natural terrain mitigation measures in Hong Kong. Internationally, these measures are largely located in sparsely populated areas and landscape treatment is not particularly common. The guidance provided in this Chapter is therefore based on limited practice. There is scope for further innovation and development in this area.

5.2 Landscape Considerations

Natural terrain is environmentally sensitive. The ecological and visual impacts of natural terrain landslide mitigation works should be fully assessed and taken into account in the detailed design. Landscape treatment for mitigation works should be compatible with the surrounding natural environment, and should be visually acceptable and ecologically sustainable.

The extent of mitigation works, including both temporary and permanent access routes, should be minimised where practicable. This will help to reduce the disturbance of existing vegetation and related fauna.

Landscape softworks are generally preferred because they can integrate with the natural environment far more easily. Vegetation may also provide some bioengineering benefits. Species chosen for planting should preferably be native and/or those already present in the surrounding flora, so that the planting works will be self-sustainable and will enhance existing ecological habitats. In some cases, natural re-generation of vegetation may be considered as an alternative to landscape softworks in areas affected by site clearance and/or engineering works. However, it should be recognised that the natural re-generation process may take some time to establish.

Apart from in-situ stabilisation works (e.g. soil nailing, boulder treatment works) at hazardous areas, most mitigation measures comprise some form of debris resisting barriers along the runout path, or at deposition zone. These measures, together with their potential landscape treatments, are described in GEO Report No. 256 (AECOM, 2010).

Mitigation measures should be placed at appropriate locations to minimise their visibility to the public. The selection of aesthetic treatments for mitigation works should take into account the site conditions and proximity of the nearby visually sensitive receivers (e.g. residents of nearby high-rise buildings). If these receivers are a long way from the measures, the use of fine texture treatments may not be effective to soften the overall visual impact. Instead, suitable colour treatment or provision of screen planting may be more appropriate. For small-scale mitigation measures, the visual impact may be insignificant, particularly where the surrounding vegetation can provide a visual screen.

5.3 Engineering Approaches for Particular Hazards

5.3.1 Open Hillslope Failure Hazards

Open hillslope hazard mitigation works are often associated with areas where there have been previous landslides, or areas of severe erosion. Where in-situ stabilisation works (e.g. soil nailing, surface protection, drainage) are proposed at source areas, landscape treatments suggested for similar types of works on man-made slopes may be applicable (see Chapter 4). Bioengineering techniques discussed in Section 2.6 may also be useful for areas that are subject to severe erosion. Open hillslope mitigation measures may also include provision of flexible barriers at the lower part of the hillside, the landscape treatment of which is discussed in Section 5.4.1.

5.3.2 Channelised Debris Flow Hazards

There are three major zones along a potential channelised debris flow path where mitigation works may be considered. These are illustrated in Figure 5.1 and comprise the following:

(a) Source Area, where a landslide or major erosion may occur, or has occurred.

(b) Runout Path, usually a natural drainage line, where landslide material originating in the source area travels along the path.

(c) Deposition Zone, where the debris comes to rest and deposits.

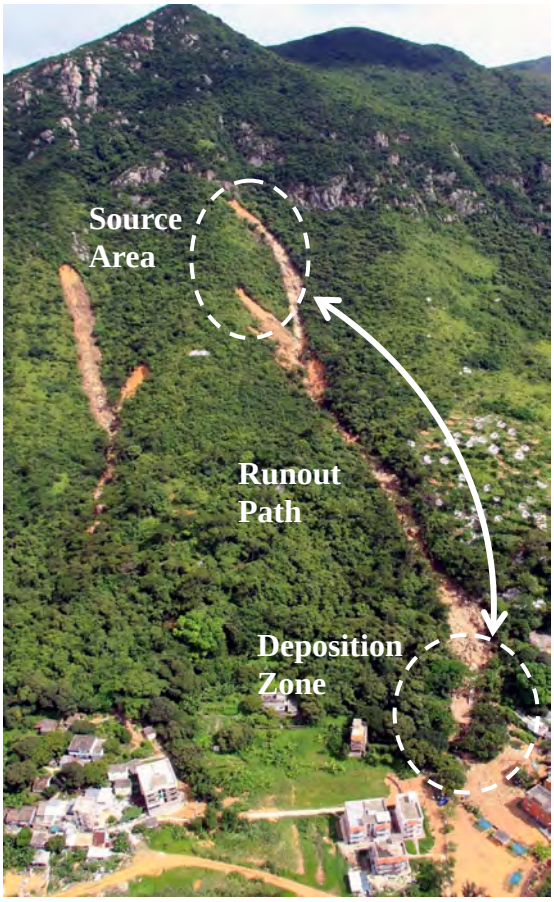


Figure 5.1 Zones along a Potential Debris Flow Path

Mitigation measures and the associated landscape treatment for channelised debris flow hazards in source areas will likely be similar to those for open hillslope hazards. However, it should be noted that source areas of channelised debris flows are usually at high elevations and may often be a considerable distance from the nearest road access.

Where emergency or repair works are to be carried out at source areas, appropriate provisions for future landscape treatment should be allowed for in the design, in order to minimise the long-term visual impact.

Figure 5.2a illustrates a drainage line in which a channelised debris flow has occurred. The best landscape approach for this drainage line may be to do nothing, given the lack of soil to plant screening vegetation. Figure 5.2b shows a typical boulder strewn drainage line, for which a barrier may need to be provided.

(a) Rocky surface in a dry drainage line

(b) Boulder strewn ephemeral drainage line

Figure 5.2 Examples of Possible Locations Requiring Natural Terrain Landslide Mitigation Measures

Along the debris runout path, mitigation measures will typically comprise rigid and/or flexible barriers. Rigid barriers may be in the form of reinforced concrete or steel structures (sometimes referred to as check dam structures), which can accommodate a large volume of debris material. Maintenance access may be required for necessary structural repair and debris removal. The locations of barriers and alignments of maintenance accesses should be carefully planned to minimise the extent of disturbance to existing vegetation, without detracting from their intended functions.

5.3.3 Rockfall and Boulder Fall Hazards

Rock and boulder falls on a natural hillside may result in boulders or rock fragments sliding, bouncing and/or rolling down slope, posing safety hazards to areas below. The travel path of rock/boulder falls is sometimes difficult to determine. The hazards presented may be addressed by in-situ stabilisation (e.g. rock dowel, dentition), or by providing flexible barriers near the facilities of concern.

5.4 Landscape Treatment of Engineering Works

5.4.1 Treatment of Flexible Barriers

Where a flexible barrier is to be constructed on a vegetated slope, it will be more acceptable, from a landscape perspective, for the barrier to be located within a narrow passageway surrounded by existing vegetation, rather than placed in front of the vegetated area. This approach should ensure that visual screening is achieved from the outset (see Figure 5.3). If there is insufficient vegetation coverage, trees and shrubs can be planted in front of the barrier, but these may take time to develop an effective screen. The barrier may also be used as a support for climbing plants. The aesthetic treatment of flexible barrier usually involves selection of an appropriate colour to better match the surrounding landscape.

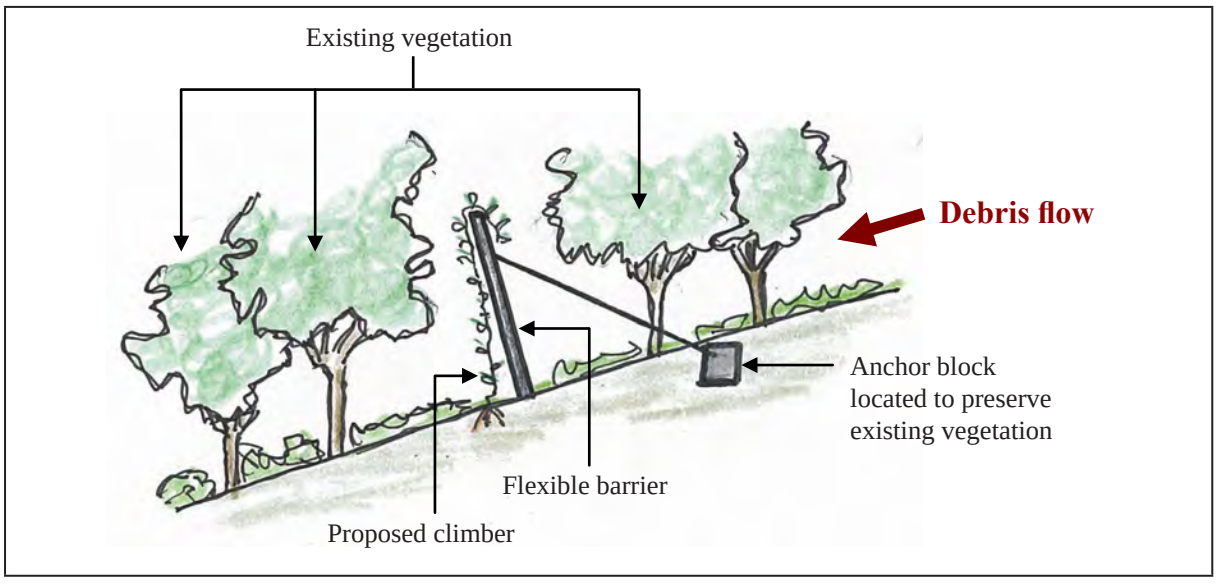


Figure 5.3 Locating Flexible Barriers

A continuous flexible barrier should preferably be split into sections, with shorter sections in a staggered arrangement (see Figure 5.4). This will provide openings for animals to pass through and facilitate access for inspection and maintenance.

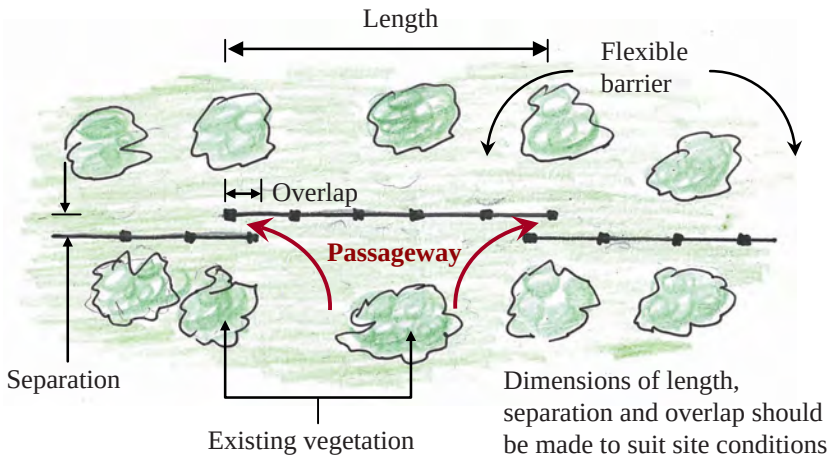


Figure 5.4 Staggered Arrangement of Flexible Barriers

5.4.2 Treatment of Rigid Debris Resisting Barriers

Landscape treatment for debris resisting barriers should be to screen the structure from view by using existing and new vegetation. Aesthetic treatment of the exposed faces of the barriers will also soften their appearance (see Section 2.4). These approaches may be supplemented by the provision of planters above and below a barrier, together with wire mesh netting fixed to the wall face which would serve as a trellis to support the growth of climbers.

Planters can be incorporated into the structure of a rigid barrier to provide planting opportunities, allowing climbers and trailing plants to be established, as illustrated in Figure 5.5. Where gabions are used, opportunities for inclusion of soil bags within the gabion structure, as described in Section 2.3.3, will provide further opportunities for landscape treatment.

Figure 5.6 shows examples of potential landscape treatments for a sizeable barrier structure, as these are often located in the deposition zone. Figure 5.7 shows that screen planting has been provided in front of a barrier to reduce the long-term visual impact.

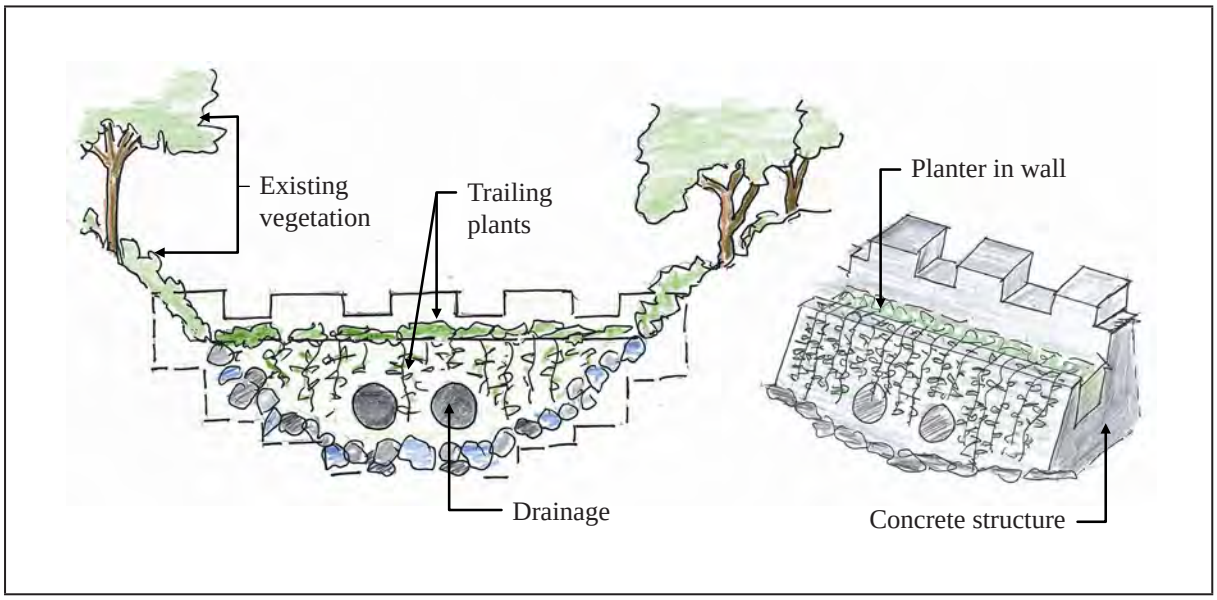


Figure 5.5 Schematic Arrangement for Greening a Rigid Barrier

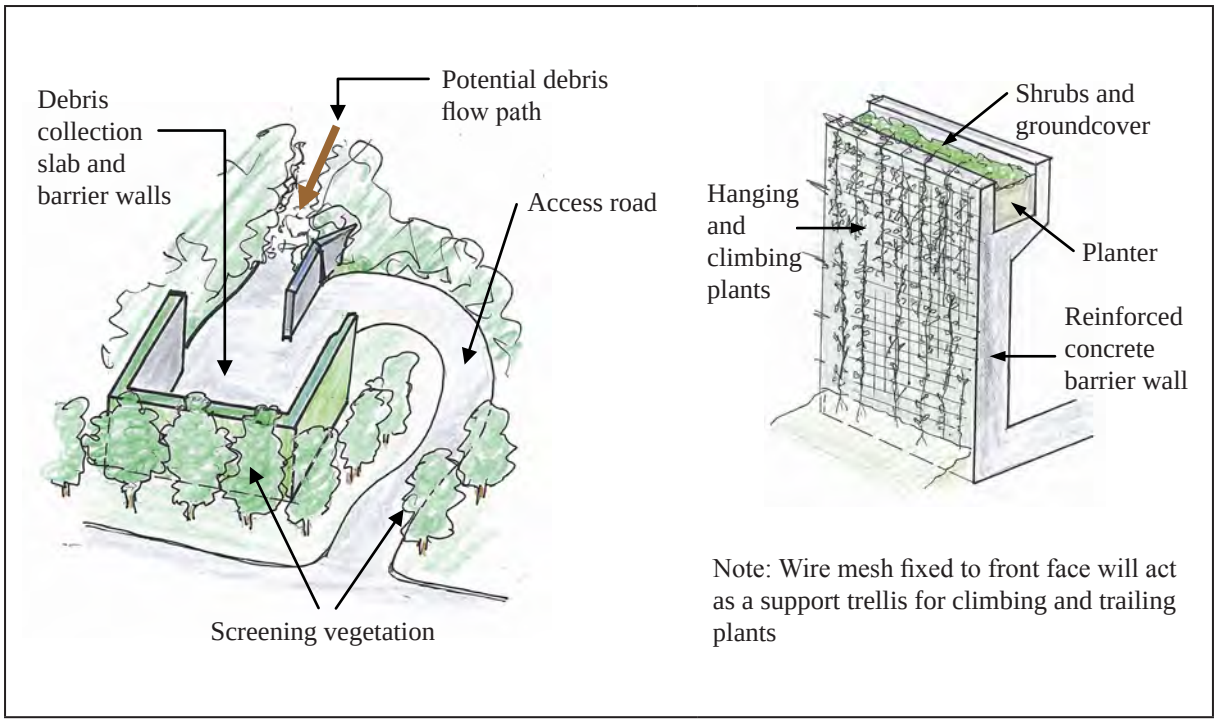


Figure 5.6 Landscape Treatment for Sizeable Barrier Structures

Apart from the examples discussed above, GEO Report No. 256 (AECOM, 2010) also provides useful recommendations and examples of a variety of potential landscape treatments. The extent to which these may be provided will be dependent on the location and sensitive nature of the particular site, together with cost effectiveness considerations.

- Barrier painted a subdued colour to reduce visual impact; note that the paint has been applied with a mottled effect to further reduce the initial visual impact
- Screen planting has been provided in front of the barrier to reduce the long-term visual impact

Figure 5.7 Example of Barrier Structure in the Deposition Zone

5.4.3 Treatment of Rockfall and Boulder Fall

In-situ stabilisation works for rocks and boulders on natural terrain are relatively small-scale. The visual impact of the works should be insignificant, particularly where an effective screening is provided by the surrounding vegetation.

Landscape treatment might include landscape hardworks to concrete elements and the provision of climbers or screening vegetation. Where flexible barriers are considered necessary, guidance on landscape treatment is given in Section 5.4.1.

6 Landslide Repairs

6.1 General

This Chapter provides guidance on landscape works associated with landslide repairs and the potential use of bioengineering applications for this purpose. The prime objectives of landslide repair are to address safety issues and reinstate the area as far as practicable. Opportunities may also be taken to improve the landscape.

6.2 Landslide Repair Works

After mitigating the immediate danger of a landslide, the affected terrain may be considered for more substantial repair or upgrading works, to prevent further deterioration and improve the safety margin. The nature of the engineering design and associated landscape treatment for landslide repair works is likely be similar to that described in Chapter 4 for man-made slopes and in Chapter 5 for natural terrain.

Figure 6.1 shows a successful example of landslide repair works in which the landscaped appearance of the failure scar has progressively improved over time and now blends in with the natural surroundings.

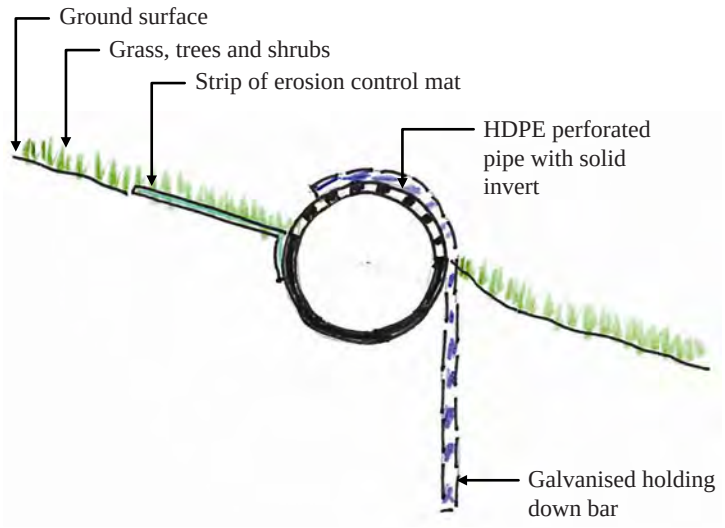
(a) Large failure in 1992 left an unsightly scar on the natural hillside

(b) Progressive improvement in landscaped appearance after 7 years

(c) Landscape softworks blend in with the natural surroundings (September 2011)

Figure 6.1 Reinstatement of Natural Terrain Landslide Scar

Perforated high density polyethylene (HDPE) pipes are commonly used, as an alternative to concrete drainage channels, on relatively gentle slopes within landfill sites. The use of HDPE pipes for landslide repairs could be considered, as it is relatively easy to install, inexpensive, and potentially less visually intrusive than a concrete drainage channel. However, a drawback that should be considered before adopting this option is that the interior condition of the pipe is often difficult to inspect after installation. Figure 6.2 illustrates the engineering detail and provides an example indicating that the pipe remains functional several years after installation.



(a) Engineering detail for HDPE drain

(b) Example of a HDPE drain still functioning after several years, despite presence of leaf litter

(c) Connection detail with concrete drainage channel

(d) Interior of above HDPE drain clear of litter or debris

Figure 6.2 Alternative HDPE Surface Drain Pipe

Where sufficient soil remains on the scar area, planting can be considered, as for man-made slopes or natural terrain. Consideration should be given to planting of native species and/or those found in the surrounding landscape areas. In combination with the natural dispersal of plant species, a vegetated landscape compatible with the natural surroundings can be established.

Natural dispersal or invasion of surrounding species into the failure area will occur on most natural terrain affected by landslides. This natural re-generation process, despite taking time, should result in the formation of a vegetated and sustainable landscape. Figure 6.3 provides an illustration of this for a landslide above Yu Tung Road.

(a) Photograph taken after the failure in June 2008

(b) Photograph taken about 1 year after failure

Figure 6.3 Self-seeded Re-vegetation of Natural Terrain Landslide

Landslides may strip off much of the top soil at the source areas, which will affect the future growth of vegetation. Where a vegetated surface is desired, fast growing species of groundcover plants may be applied in localised soil pockets. *Wedelia trilobata* has been found to be effective in restoring degraded landscapes. However, this species is considered to be invasive and it may quickly spread to adjacent areas where conditions may be favourable. Hence, care needs to be exercised with its use.

In the case of emergency landslide repairs, sprayed concrete is often used to protect the failure surface from further water ingress, erosion and potential instability. There will be situations where the concrete surface may need to be retained in the subsequent landslide repair or upgrading works. In such circumstances, the designers should consider applying landscape treatment for the retained hard surfacing. Simple colour painting may be an acceptable option to reduce the visual impact. Further improvement could be made by providing openings in the concrete surface for planting of climbers, as shown in Figure 6.4. Alternatively, consideration could be given to innovative solutions, such as the formation of terraces on the hard surface (see Figure 4.11) to maximise the opportunities for planting.

(a) Sprayed concrete applied in the short-term as emergency works

(b) Subdued paint applied to the sprayed concrete with openings for planting to reduce its visual appearance

(Note: These are the same natural terrain failures shown in Figure 5.1 after emergency works)

(c) Distant view of landslide scars after landscape works

Figure 6.4 Coloured Sprayed Concrete for Emergency Landslide Repair Works with Openings for Planting

6.3 Soil Bioengineering Applications for Landslide Repairs

Bioengineering applications in Hong Kong are discussed in Section 2.6 and a list of common bioengineering techniques that have been applied in Hong Kong is summarised in Table 2.8. GEO Report No. 227 (Campbell et al, 2008) provides useful commentary on and evaluation of bioengineering techniques, both generally and specifically for landslide repairs. Cheung et al (2011) also provide details of bioengineering trials.

All vegetation provides some bioengineering benefits, particularly against surface erosion. For landslide repairs, bioengineering approaches are suggested for:

(a) situations, particularly on open hillslope, where emergency works are not required and all that is necessary for repair is debris removal, trimming of the landslide backscarp and improvement of the erosion resistance,

(b) repairing hillsides affected by surface erosion (i.e. for repair of shallow erosion type failures, possibly in combination with some conventional engineering measures), and

(c) reducing the rate of hillside deterioration.

However, bioengineering measures may not be applicable for the following:

(a) where there is little depth of soil to support vegetation,

(b) for slopes steeper than 55°, and

(c) for deep failures with a high back scarp.

7 Supervision of Landscape Works

7.1 General

The success of landscape treatment will depend ultimately on its implementation. Key to this is the strict compliance of works with the design drawings and requirements in the GS and PS. Care should be exercised by both the Contractor and supervisory staff in carrying out the landscape works. Hence, suitably experienced personnel should be engaged to ensure that all the necessary requirements are fully implemented. Briefing/training on specific landscape requirements of the contract should be given to all workers involved before commencement of works and site safety issues should be addressed.

Those responsible for supervising the implementation of landscape works may find it useful to draw up inspection checklists of tree and vegetation protection measures, materials and workmanship items for planting, landscape hardworks and establishment of landscape softworks, similar to those in Appendix G.

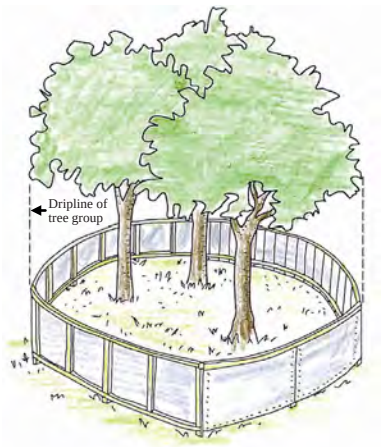
7.2 Tree Protection Works

The implementation of tree protection works should be considered at all stages of slope works, including the maintenance operations at maintenance stage. Table G1 of Appendix G provides a list of typical tree protection measures requiring supervision. Particular attention should be paid to the following:

(a) Identification of all trees/vegetation to be retained and any necessary protection zones.

(b) Establishment of protection around trees (see Figure 7.1) and along site boundaries adjoining areas of vegetation.

(a) Protective wrapping around tree trunks



(b) Tree protection zone

Figure 7.1 Measures to Protect Existing Trees

(c) Exclusion of works and other disturbance from these areas.

(d) Installation of any specified supports or protective structures.

(e) Ensuring that protective wrapping materials around trees do not cause decay or fungal growth on the trees. This could be achieved by using porous and non-moisture holding materials for tree wrapping, or by using wooden battens between the wrapping and the tree trunk.

These measures, together with those recommended in DEVB (2010c), need to be implemented before the commencement of construction works, and should be maintained throughout the construction period. The contract requirements relating to tree protection works should be discussed and understood by all parties before the works commence. Much of the damage to vegetation to be retained typically occurs at the beginning of construction works, and the damage done often could not be compensated. Damage may be caused to the following:

(a) Branches and tree canopy, through impact damage from lifting operations, or desiccation by exhaust fumes from equipment and generators.

(b) Trunks, through impact damage from construction vehicles, or from the use of the space around the trunks for storage/work activities.

(c) Roots, through impact damage by compaction equipment, movement or storage of heavy objects, desiccation by dewatering, contamination from flooding or spillage of liquids, destabilising through severance of roots, or undermining of the root ball by excavation within the tree protection zone.

(d) Tree health, through engineering works (e.g. excavation, grouting, concreting, drilling works). The attention of supervisory staff should be drawn to the need to ensure that the tree body and root system are not contaminated by cement during shotcreting/grouting works.

The nature and locations of trees can pose unique challenges for the installation and maintenance of tree protection measures. In non-standard cases, supervisory staff may request the Contractor to submit relevant method statements for approval.

Opportunities exist in supervising works to minimise disturbance of retained trees through localised adjustment of the engineering works. Where excavation is necessary within the tree protection zone, requirements of the works are given in Clause 26.11 of the GS. Where practicable, use of hand tools for excavation is recommended and roots larger than 20 mm diameter should be left in place. If cutting of roots is unavoidable, advice on the potential effects on tree health and stability should be sought from an arborist. Advice from

the designer should also be sought where tree rings are proposed to be enlarged, or combined on site.

Where tree felling is included in the works, existing roots may need to be removed. The void left should be filled with soil material, but if the slope is steep the void may need to be filled with soil cement, or concrete.

Photographs are an important aid in supervision of the protection of existing vegetation and for planting works. They should be taken at the commencement of the contract to show the condition of the existing vegetation, at regular intervals during the contract (e.g. for government projects, bi-monthly photographs are specified in the GS), and upon completion as part of the agreed record of the works.

7.3 Supervision of Landscape Softworks

Specifications for planting works should include aspects that need to be taken care of by supervisory staff. However, uncertainties may arise, for instance, in the correct identification of plant specimens that are to be planted, or in determining acceptable standards of quality in the plant material to be used. Hence, advice from the landscape designer, or other specialists, should be sought as appropriate.

Table G2 in Appendix G provides a list of typical landscape softworks items requiring supervision. Supervisory staff should give particular attention to the following:

(a) The extent of excavation for planting pits, so that disturbance of the slope and potential for surface erosion can be minimised. Planting pits should be filled with appropriate soil-mix as defined in the GS.

(b) Careful handling of new plants to ensure that they are not damaged during transportation to or around site.

(c) Planting through erosion control matting, where the matting needs to be cut or adjusted to allow planting.

(d) Installation of stakes, guys, etc. at the time of planting where necessary to ensure plants are fully supported.

(e) The essential need for thorough watering of newly installed plants on the day that they are planted.

(f) The need to reinstate vegetation in works areas used for slope works.

A comprehensive photographic record should be kept of the landscape softworks.

7.4 Supervision of Landscape Hardworks

Supervision of landscape hardworks should focus on ensuring the quality of materials and workmanship for the aesthetic treatment of any exposed surfaces of engineering and slope furniture elements. The quality standard of aesthetic finishes can be difficult to evaluate on site. If in any doubt, supervisory staff should seek direction from the landscape designer.

Table G3 of Appendix G provides a list of items associated with the construction of engineering and slope furniture elements which could affect the quality of the subsequent landscape hardworks. Key considerations in the supervision of landscape hardworks include:

(a) The co-ordination of hard surface finishes with any underlying engineering elements (e.g. drain covers or expansion joints) to ensure that their quality is not compromised.

(b) Attention to the workmanship in forming straight/even edges, or joints.

(c) Ensuring fixing or filling materials do not compromise the intended surface finish (e.g. overfilling of joints in a masonry block surface so that the mortar obscures the appearance of the stone).

(d) Correct alignment and orientation of features, and that finishes are set to a consistent pattern.

(e) Ensuring any fabrication, cutting or modification of materials on site does not compromise the quality of the material, or surface finish.

(f) The construction of an in-situ trial panel of a surface finish will be beneficial to verify its finished appearance and standard of workmanship, and allow adjustments in the technique prior to undertaking the works. If the panel is acceptable, it can be retained as part of the built works.

Figure 7.2a illustrates a masonry block surfacing where blocks were removed to accommodate soil nail heads and then reinstated. Figure 7.2b shows the importance of matching the colour of the new render to the existing. A trial panel of mortar pointing should have been prepared with a view to achieving a better quality and product.

A comprehensive photographic record should be kept of the landscape hardworks.

(a) Satisfactory appearance of soil nails heads beneath stone pitching

- Careful removal of masonry prior to soil nailing
- Reinstatement of masonry after completion of soil nails with matching render

(b) Unsatisfactory appearance of soil nails heads beneath stone pitching

- Shows the importance of matching the colour of the new render to the existing; use of a trial panel would probably have resulted in a better end product

Figure 7.2 Reinstatement of Masonry Facing after Soil Nailing

7.5 Supervision during the Establishment Period

The intention of establishment works for planting is to provide necessary horticultural care to ensure that newly installed plants can establish and grow to a point where they can support themselves. Clauses 3.79 to 3.93 of the GS stipulate the requirements and Table 7.1 provides a checklist largely based on these requirements.

Supervisory staff should ensure the attendance by the Contractor, and that the establishment works are carried out regularly and as thoroughly as reasonably practicable, taking into account the important requirement of the safety of workers. The Contractor should also be asked to provide a specific risk assessment and method statement, with

particular focus on safety issues, for works during the Establishment Period. Close monthly monitoring and reporting of all establishment work activities are essential.

Table 7.1 Horticultural Operations during Establishment Period

Maintenance Operation (Notes 1 & 2)	Description
General inspection	Inspection of landscape works and checks should be carried out at monthly intervals to determine the establishment works required.
Check for pests and diseases	
Non-organic litter removal	Removal/clearing of non-organic litter should be carried out as needed. It is suggested that organic matter (e.g. dead plant matter) on slope surfaces, which are beneficial to soil improvement (both chemical and physical) and succession of the plants, should be kept in place where possible.
Watering (Note 3)	Planted material will need to be watered at regular intervals and the need for watering is dependent on natural precipitation, weather conditions, period elapsed since planting, groundwater levels, topography and soil conditions (see Clause 3.84 of the GS).
Replacement planting	The need should be reviewed monthly and replacement should be carried out within 14 days thereafter. Only replacing plants at the end of the Establishment Period is not acceptable.
Grass cutting	Where necessary, grass cutting should be carried out two to three times during the Establishment Period, preferably in June or July when young seedlings are competing. Category 3 hydroseeded grass (see Clause 3.87(4) of the GS) may only need cutting if it is to be later maintained as mown grass, except that it should be cut to ensure drainage channels and maintenance access are kept clear.
Weeding	Weeding should be carried out on an as need basis and is important for planting in crest, berm and toe planters and to keep drainage channels and maintenance access clear.
Pruning	If necessary, depending on the species and purpose of pruning, preferably before and after the growing season.
Fertilising	Shall be applied not less than 100 days and not more than 300 days after grassing or planting (see Clause 3.89 of the GS). Two applications are recommended within this time period. One of the applications should be ahead of the main growing season, if possible.
Mulching	If necessary, ahead of the dry season.
Staking and tying	Should be carried out in conjunction with planting. Regular inspection (say, 6 monthly) should be carried out to make necessary adjustments and ensure these do not constrict or impede growing tree trunks.

Notes:
(1) Adequate safety measures should be provided for workers in carrying out the establishment works, particularly on steep slopes.
(2) For establishment works on steep slope faces, the frequency and need for these operations should take account of the safety of workers.
(3) Hydroseeded grass may not require watering unless it shows sign of wilting.

During the Establishment Period, plant species from adjacent areas may disperse or invade into areas that have been planted. This natural recruitment should be recognised as being beneficial to the long term sustainability of the landscaped slope, especially where the species are from an area of native vegetation. Some species may, however, be regarded as invasive or undesirable. In the course of inspections during the Establishment Period, maintenance agents may require removal of these species. Where such a request is made, it may be necessary to provide photographs of the species, so that the Contractor and supervisory staff can accurately identify them on site.

The Establishment Period typically commences after the completion of main construction works, including planting works. Supervisory staff may have left the site by that time and in such cases, the Engineer for the works contract must ensure that the necessary inspections and specified establishment works are carried out properly.

Photographs should be taken at regular intervals during the Establishment Period. A representative selection of photographs taken at the end of the Establishment Period should be included in the MM.

8 Maintenance of Landscape Works

8.1 General

This Chapter provides guidance on the long-term maintenance of landscape softworks and hardworks, which will become the responsibility of the slope owner. For Government slopes, this will be a Government department to which slope maintenance is allocated. For private slopes, this will be the responsibility of the lot owners.

The slope works designer should provide the slope owner with a Maintenance Manual (MM) containing records of the as-built works and guidance for their subsequent long-term maintenance operations.

Technical guidance on the maintenance of slopes is provided in the *Geoguide 5 - Guide to Slope Maintenance* (GEO, 2003a). Guidance aimed primarily at the general public and private lot owners is provided in the *Layman's Guide to Slope Maintenance* (GEO, 2003b).

The slope owner should make arrangements, either directly or through a maintenance agent, for the regular inspection of vegetation and hard landscape surfaces, and undertake any necessary maintenance to ensure satisfactory performance in accordance with the intended function. Tree protection works may be required in undertaking maintenance operations (see Section 7.2).

The risks associated with undertaking maintenance inspections and/or works on slopes and/or at height should be considered to ensure that the safety of workers and supervisory staff, who may be required to carry out maintenance inspections and/or works, is properly addressed.

8.2 Handover and Long-term Maintenance of Landscape Softworks

The slope owner should agree with the selection and design of all landscape softworks prior to commencement of any construction. Their representatives should be invited to inspect the landscape softworks prior to substantial completion, and again at the end of the Establishment Period, and should check that all necessary facilities, including maintenance access, have been incorporated.

8.2.1 Maintenance of Grass and Groundcover Plants

Grass and groundcover plants may grow rapidly and are therefore often chosen to achieve a quick vegetative cover to a soil slope. These generally require regular cutting/trimming to stimulate root growth, which can enhance resistance to surface erosion. However, some grass species and groundcover plants (e.g. *Liriope spicata*) do not require cutting due to their non aggressive growth form. Grass and groundcover plants may also spread into drainage channels and regular clearance of these may be required.

Grass and groundcover areas may eventually become colonised by self-seeded trees and shrub species. This is not considered detrimental in respect of protection to the slope surface and indiscriminate removal of all unplanned vegetation should be avoided. Removal should only be considered if the self-seeded plants are regarded as an invasive or undesirable species, likely to have an adverse effect on the intended landscape.

8.2.2 Maintenance of Woodland Vegetation

Woodland vegetation typically comprises seedling trees and shrubs, together with herbaceous plants. Once the woodland has fully established, it should be self-supporting and should need minimal recurrent maintenance.

As the trees and shrubs grow and their canopies close, the grass and groundcover species can get shaded out, to the extent that they have only a sparse or thin coverage at ground level, with occasional bare patches. This is normal and may not affect the bioengineering functions of the woodland vegetation. If potential erosion of the ground surface is of concern, shade tolerant groundcover species should be planted (see Appendix F), possibly in conjunction with an erosion control mat.

Fast growing pioneer tree species, which establish quickly and help to create a sheltered micro-climate at ground level, could promote the development of slower growing native species. However, if these pioneer species become very dominant and inhibit the growth of other plants, removal and/or thinning of them may be considered, typically 5 to 8 years after planting. Slope owners should be informed of this requirement when pioneer species are planted.

Selective thinning of woodland can also be undertaken at any time to create space between the trees, to promote woodland structure, to allow more light to reach the ground layer vegetation, and to reduce the potential for wind damage during typhoons. Suggestions for any thinning of the woodland vegetation should be included in the MM. Table 8.1 provides a checklist of typical maintenance operations for grass/groundcover and woodland vegetation, and the suggested frequency with which they should be undertaken.

Other woodland vegetation maintenance operations that might need to be addressed in the MM include:

(a) As for landscape softworks generally invasive species, such as *Leucaena leucocephala* (銀合歡) or *Mikania micrantha* (薇甘菊), may disperse or invade into the woodland areas and should be removed if they are likely to adversely affect the intended landscape.

(b) Cutting or enlargement of openings in wire mesh used to support erosion control mats may be necessary to allow space for tree and shrub species to grow through the mesh. Figure 8.1a illustrates an example where a small self-seeded tree stem is severely restricted and may need to be removed to avoid the possibility of the tree falling as it continues

to grow. Figure 8.1b shows a tree where the maintenance party has cut the wire mesh to prevent the tree from being affected.

(c) As trees and shrubs grow, they may obstruct vehicle and signage sightlines, block lighting, or inhibit safe traffic or pedestrian movement. When this occurs, pruning will be necessary. Guidelines on trimming and pruning are provided by DEVB (2007 & 2010d). Suitably experienced contractors should be employed for any trimming and pruning works and under the direction of an experienced arborist.

(d) Periodic tree risk assessments may be required as a component of overall tree management operations for trees on slopes and retaining walls where any failure (e.g. a branch fall) may pose a threat to public safety. Assessment of tree risks and consequential recommendations should follow the guidelines and checklist provided by DEVB (2011a) and advice of an experienced arborist/tree specialist should be sought.

Table 8.1 Long-term Maintenance Operations for Landscape Softworks

Maintenance Operation	Frequency
Grass/Groundcover Vegetation	
General inspection	Once a year
Inspection for fungal/viral attacks and pest infestations; treatment as necessary	As required
Repair after damage (erosion, vandalism, storm, fire, etc.)	As required
Clearance of non-organic litter from vegetated surfaces	As required
Grass cutting/groundcover trimming and removal of invasive species	As required
Clearance of drainage channels and maintenance of slope access routes	Once a year
Woodland Vegetation	
General inspection	Once a year
Inspection for fungal/viral attacks and pest infestations; treatment as necessary	As required
Replacement of plants after damage (erosion, fire, typhoon, vandalism, etc.)	As required
Clearance of non-organic litter from vegetated surfaces	As required
Selective thinning and/or enhancement of species as required and removal of invasive species	As required
Pruning to remove tree hazard	As required
Clearance of drainage channels and maintenance of slope access routes	Once a year

(a) Tree trunk choked by wire mesh

(b) Wire mesh has been cut to allow tree to grow

Figure 8.1 Tree Trunk Choked by Wire Mesh

8.3 Maintenance of Landscape Hardworks

The slope owner should agree with the selection and design of all landscape hardworks prior to commencement of any construction.

Landscape hardworks should require little maintenance other than ensuring that weepholes through the hard surfacing and slope drainage are kept clear and functional. The guidance provided in Geoguide 5 (GEO, 2003a) should be followed. Typical maintenance operations for hard landscape surfaces are shown in Table 8.2.

Inspection and/or maintenance of engineering elements and hard landscape surfaces should not cause any adverse impact to the existing slope vegetation. If vegetation clearance is necessary for inspection or maintenance works, the extent should be minimised and cutting of roots should be avoided.

Table 8.2 Long-term Maintenance Operations for Landscape Hardworks

Maintenance Operation	Frequency
General inspection	Once a year
Clearance of litter	As required
Repair of defects or areas that have been damaged	As required
Cleaning of hard landscape surfaces that have become stained or discoloured, in order to retain their aesthetic function. Colour may need to be re-applied to concrete surfaces where this has faded over time (not necessary if the surface has weathered and darkened to a more natural appearance).	As required
Clearance of drainage channels and maintenance of slope access routes	Once a year

8.4 Routine Maintenance Inspections, Engineer Inspections and Maintenance Manuals

Geoguide 5 (GEO, 2003a) provides guidance on the preparation of slope MM and suggests requirements for Routine Maintenance Inspections (RMI) and for Engineer Inspections (EI) of slopes.

Table H1 in Appendix H provides a checklist of typical landscape items which should be considered for inclusion in a slope MM. Checklists of landscape items for inspection during RMI and EI are given in Tables H2 and H3 respectively (Appendix H).

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Appendix A

Examples of Application of the Landscape Guidelines

This Appendix provides examples of slope works to illustrate the process of landscaping considerations for an integrated engineering/landscape design on various types of man-made slopes and natural terrain mitigation measures. Their design considerations essentially follow the main headings of the checklist in Appendix D and include:

- Site characteristics and site-specific constraints
- Environmental setting
- Stakeholders' views
- Landscape concept
- Planting opportunities (landscape softworks)
- Visual improvement of engineering and slope furniture elements (landscape hardworks)

The examples also illustrate landscape related construction precautions, the outcome of the completed works and possible maintenance and sustainability needs. The examples are intended to illustrate the guidance provided in this Publication and are not intended to serve as standard checklists, or standard methods for landscape design.

In addressing the above considerations, it will likely be necessary to balance an initial landscape concept as recommended in Section 3.2 against other factors. This has been the case in some examples illustrated herein, where the practicability of achieving the initial landscape concept would have to be considered. This balancing exercise will be common to many landscape designs for slope works and some compromises may be necessary.

Other factors which may require a re-think of an initial landscape concept include stakeholders' views, access difficulties and/or site safety for establishing planting on steep slopes, or geological conditions not suitable for planting.

Table A1 List of Examples

Example	Description	Setting
A1	Landscape Softworks to a Hard Surfaced Soil Cut Slope	Roadside
A2	Landscape Softworks and Hardworks to a Hard Surfaced Soil Cut Slope	Village
A3	Landscape Hardworks to a Masonry Retaining Wall with Wall Trees	Urban
A4	Landscape Softworks with Soil Nailed Grillage System for a Vegetated Fill Slope	Rural
A5	Landscape Softworks and Hardworks for Site Formation of a New Rock Cut Slope	Roadside
A6	Landscape Softworks to an Existing Rock Cut Slope	Roadside
A7	Landscape Softworks to Flexible Barriers	Natural Hillside
A8	Landscape Softworks to Debris Resisting Barriers	Natural Hillside

Example A1 - Landscape Softworks to a Hard Surfaced Soil Cut Slope (Roadside Environment) **Sheet 1 of 2**

Slope before upgrading works (2001)

Site Characteristic and Constraints
- 16 m high, 50° soil cut slope
- Existing sprayed concrete surface cover
- Extensive vegetation on 30° natural terrain above crest (i.e. constraint for cutting back the slope)
- Narrow footpath and road at the slope toe (i.e. a constraint for providing a sizeable toe planter)

Environmental Setting
- Reasonably exposed to sunlight (east-facing)
- Minimal potential shading problem, i.e. no significant overhanging trees
- Rural road at slope toe; not heavily trafficked; minimal wind effects or air pollution
- Adjacent woodland comprising exotic and native species including some small trees

Stakeholders' Views
- Support for removal of existing hard surfacing and replacement with planting
- Request to provide maintenance access and minimise future slope maintenance
- Footpath at toe to remain open during construction

Landscape Concept
- Replace existing hard surfacing with a pioneer vegetation cover; allow natural dispersal of vegetation from adjacent hillside
- Provide planting at slope toe, if possible

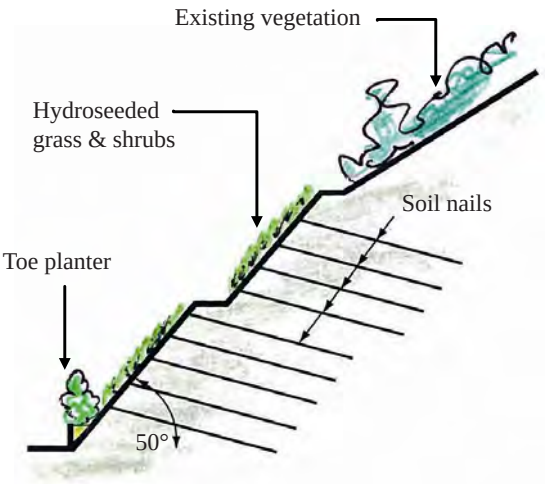
Slope Works and Landscaping Options

Option	Engineering Description (of selected option)	Landscape Considerations		
		Minimising Physical Impact	**Landscape Softworks**	**Landscape Hardworks**
1 Soil nailing (✔)	• Remove existing hard surfacing • Install soil nails • New drainage channels and maintenance access • Toe planter • Erosion control mat and wire mesh	• Retain majority of existing vegetation (i.e. least disturbance)	• Hydroseeded grass to slope surface • Groundcover plants and shrubs in toe planter	• Masonry facing to toe planter • Paint finish to exposed engineering elements and slope furniture
2 Cut back (40°)		• Considerable loss of existing vegetation and ecological habitats	• Ecological planting with pit planted larger shrubs for flatter slope area • Groundcover plants and shrubs in toe planter	
3 Retaining wall (3 m high)		• Likely loss of existing vegetation at the ends of the retaining wall • Wall surface may be visually unattractive	• Ecological planting of grass, trees and shrubs within the backfilled area • Grass and shrubs on upper portion of slope	• Masonry facing to toe planter • Paint finish to slope furniture

Example A1 **Sheet 2 of 2**

Option 1 is preferred because:

- *Lower construction cost than other options*
- *Relatively simple engineering works*
- *Least disturbance to the existing vegetation*
- *Low life-cycle cost of the landscaping works*
- *Stakeholders (District Council) preferred option*



Engineering and Landscape Works Implemented

- Soil nails and prescriptive raking drains
- New drainage system, maintenance access and handrailing
- Toe planter wall with masonry facing, groundcover plants and native shrubs
- Hydroseeded grass together with erosion control mat and wire mesh
- Painting of exposed engineering and slope furniture elements

Construction Precautions

- Protect surrounding vegetation from construction impact, dust, material spillages, etc.
- Minor adjustment of channel alignments to reduce disturbance to existing tree roots and minimise visual impact

Maintenance and Sustainability

- If trees naturally disperse onto the slope, some trimming and/or thinning may be necessary in later years

Completed Works

Completion of construction (2005)

2 years after slope upgrading works (2007)

Example A2 - Landscape Softworks and Hardworks to a Hard Surfaced Soil Cut Slope (Village Environment) **Sheet 1 of 2**

Slope before upgrading works (2000)

Site Characteristic and Constraints
- 11 m high, 60° soil cut slope
- Existing chunam surface cover and trees
- Several reported landslide incidents on the slope
- Extensive vegetation on 30° natural terrain above crest (i.e. constraint for cutting back the slope)
- Village house in very close proximity to the slope toe (i.e. constraint for providing toe planter)

Environmental Setting
- Little exposure to sunlight (northeast-facing)
- Minimal potential shading problem (i.e. no significant overhanging trees)
- Village setting with house adjacent to slope
- Vegetated hillside above the slope crest

Stakeholders' Views
- Minimise future slope maintenance
- Avoid disturbance to the villagers during construction
- As direct sensitive receivers, village house owners prefer hard surface cover

Landscape Concept
- Replace existing hard surfacing with pioneer vegetation; support natural dispersal of vegetation from adjacent hillside; provide landscape hardworks to lower portion if necessary
- Retain existing vegetation on slope where possible

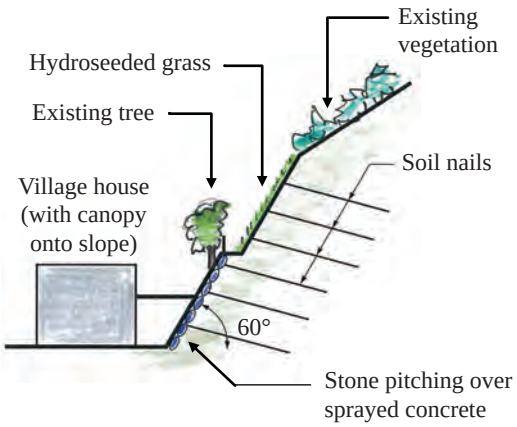
Slope Works and Landscaping Options

Option	Engineering Description (of selected option)	Landscape Considerations		
		Minimising Physical Impact	**Landscape Softworks**	**Landscape Hardworks**
1 Soil nailing (✔)	• Remove existing hard surfacing • Install soil nails • Provide hard surfacing to lower part of slope • New drainage channels and maintenance access • Erosion control mat and wire mesh to upper slope portion	• Retain majority of existing vegetation on slope and at crest (i.e. least disturbance)	• Hydroseeded grass to upper portion of slope	• Stone pitching over hard surfacing to lower slope portion behind village house • Paint finish to other exposed engineering elements and slope furniture
2 Cut back upper portion (45°)		• Loss of existing vegetation on the slope and at crest	• Grass and pit planted shrubs to the cut back portion of the slope	

Example A2 **Sheet 2 of 2**

Option 1 is preferred because:

- *Mixed soft and hard landscape solution accepted by the stakeholders (provide hard landscape treatment only at the slope portion immediately behind the village house)*
- *Lowest cost, best value for money for achieving most of the landscape concept*
- *Minimum working space required*
- *Minimise construction waste material*
- *Low life-cycle cost of the landscaping works*



Engineering and Landscape Works Implemented

- Soil nails
- New drainage system, maintenance access and handrailing; painted to soften visual impact
- Retention of most of the existing trees
- Hydroseeded upper slope with erosion control mat and wire mesh
- Sprayed concrete with granite stone facing at lower slope

Construction Precautions

- Protection of the existing trees
- Environmental control of noise, dust and surface water run-off due to close proximity to the village house
- Avoid damage to canopy attached to village house

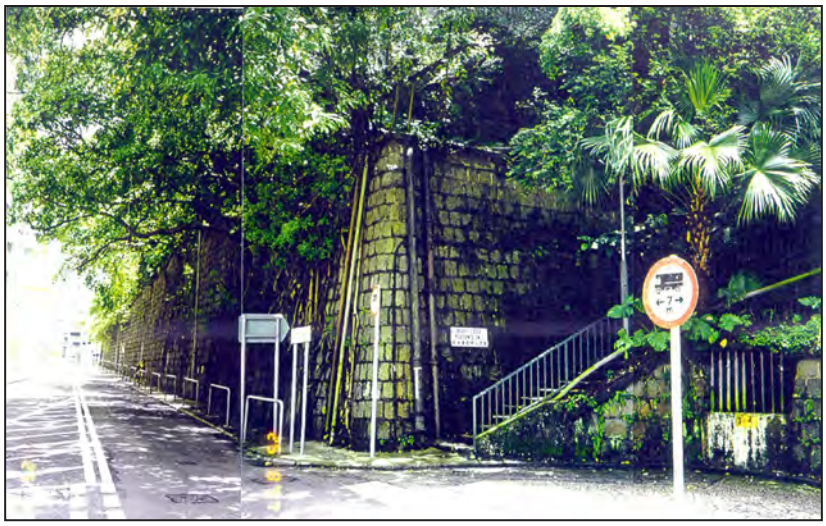
Maintenance and Sustainability

- Minimal maintenance required to lower slope portion
- Allow natural dispersal of adjacent vegetation onto the upper portion

Completed Works

Completion of construction (2001)

Example A3 - Landscape Hardworks to a Masonry Retaining Wall with Wall Trees (Urban Environment) **Sheet 1 of 2**



Masonry wall before upgrading works (1999)

Site Characteristic and Constraints

- 5.6 m high masonry wall
- Existing Chinese Banyan (*Ficus microcarpa*) trees on the wall
- Existing trees above the wall
- Narrow footpath and busy road at the slope toe (i.e. constraint for providing a facing to the wall)

Environmental Setting

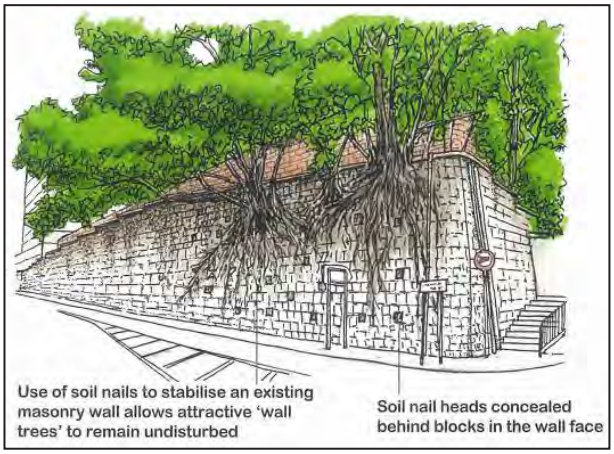
- Little exposure to sunlight (northeast-facing)
- Adjacent to other masonry walls
- Limited surrounding vegetation

Stakeholders' Views

- Wall trees must be retained and their roots protected

Landscape Concept

- Maintain existing wall appearance
- Minimise interference to wall trees



Sketch of landscape concept

Slope Works and Landscaping Options

Option	Engineering Description (of selected option)	Landscape Considerations		
		Minimising Physical Impact	**Landscape Softworks**	**Landscape Hardworks**
1 Soil nailing (✔)	• Install soil nails, spaced to avoid tree roots • Soil nail heads flush with wall	• Retain existing wall trees • Retain existing block pattern on wall	• Nil	• Granite texture finish to exposed face of soil nail heads

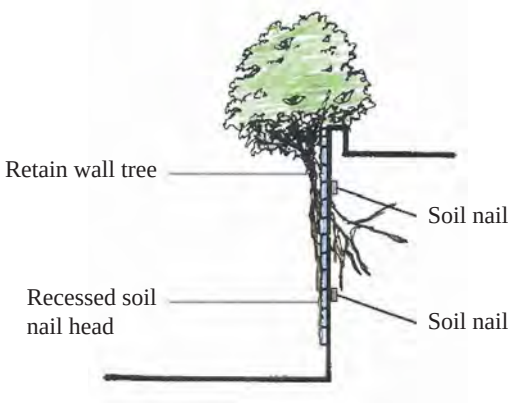
Example A3 **Sheet 2 of 2**

Option 1 is proposed because:

- *Retention of the existing wall trees*
- *Minimum disturbance to tree roots*
- *Minimum disturbance to the masonry wall*

Aspects to be considered in the design

- *Impact of soil nailing works on the tree root system*
- *De-stabilising effect of trees on masonry blocks*



Engineering and Landscape Works Implemented

- Remove masonry blocks for soil nail construction
- Install soil nails
- Replace masonry blocks with granite finish concrete
- Install prescriptive raking drains

Construction Precautions

- Monitoring the condition of existing wall trees
- Adjust locations of soil nails to avoid damage to the tree roots, as far as practicable
- Avoid disturbance to the tree root system by soil nail drilling and grouting works
- Avoid grout spill down the face of the wall

Maintenance and Sustainability

- Periodic tree health assessment to ensure public safety

Completed Works

Completion of construction (2001)

Close-up of granite texture finish to concrete soil nail head

Example A4 - Landscape Softworks with Soil Nailed Grillage System for a Vegetated Fill Slope (Rural Environment) **Sheet 1 of 2**

Fill slope before upgrading works (2007)

Site Characteristic and Constraints
- 10 m high, 35° fill slope
- Catchwater access road above, woodland natural terrain below
- Existing vegetation including some small trees on the fill slope

Environmental Setting
- Moderate exposure to sunlight (southeast-facing)
- Minimal potential shading problem (e.g. no significant overhanging trees)
- Woodland around the perimeter of the slope comprising exotic and native species including some small trees

Stakeholders' Views
- Support for planting vegetation
- Provide maintenance access
- Minimise future slope maintenance

Landscape Concept
- Retain existing trees as far as practicable
- Provide vegetated slope surface to blend in with the surroundings
- Allow natural dispersal of vegetation from adjacent hillside

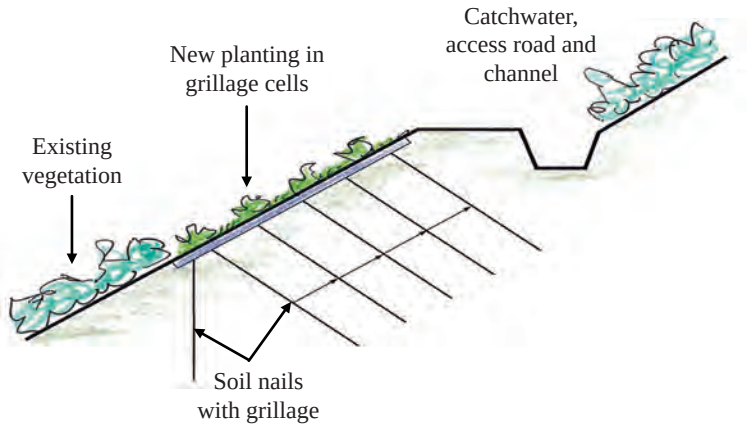
Slope Works and Landscaping Options

Option	Engineering Description (of selected option)	Landscape Considerations		
		Minimising Physical Impact	**Landscape Softworks**	**Landscape Hardworks**
1 Soil nailing with grillage system (✔)	• Clear site of small vegetation • Install soil nails • Excavate and build grillage • New drainage channels and maintenance access	• Retain majority of existing vegetation on slope and at crest (i.e. least disturbance) • Colouration of visible faces of grillage system	• Planting of small trees, shrubs and grass	• Paint or textured finish to exposed grillage and other engineering elements and slope furniture
2 Excavation and re-compaction		• Require removal of all existing vegetation • Generate large amount of waste that needs to be disposed of	• Planting of small trees, shrubs and grass	• Paint any engineering elements and slope furniture

Example A4 **Sheet 2 of 2**

Option 1 is preferred because:

- *Low construction cost*
- *Retention of existing trees*
- *Minimal disturbance to the existing vegetation*
- *Low life-cycle cost of the landscaping works*



Engineering and Landscape Works Implemented

- Vegetation clearance for soil nailing and grillage works
- Installation of soil nails and concrete grillage system
- Construction of surface drainage system
- Construction of maintenance access and handrailing
- Application of a hydroseeding mix of grass and shrubs to the slope surface together with pit planting of small trees/shrubs between concrete grillage members

Construction Precautions

- Protect surrounding vegetation and minimise disturbance as far as practicable
- Careful positioning of soil nails and drainage to avoid damage to tree root system

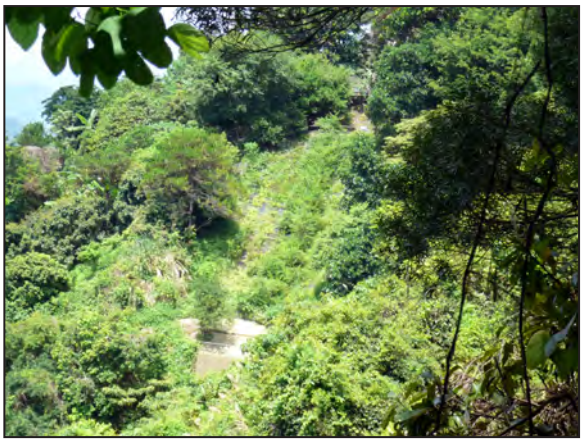
Maintenance and Sustainability

- Minimal maintenance of the vegetation
- Natural dispersal of surrounding vegetation should provide a sustainable landscape
- If trees naturally disperse onto the slope, some trimming and/or thinning may be necessary in later years

Completed Works

Slope upgrading works substantially completed (2009)

The slope is well vegetated including some natural dispersal of adjacent species (2011)



Example A5 - Landscape Softworks and Hardworks for Site Formation of a New Rock Cut Slope (Roadside Environment) **Sheet 1 of 2**

Existing cut slope before site formation works (1998)

Site Characteristic and Constraints

- 15 m high, 40° soil/rock cut slope along urban roadside
- Existing sprayed concrete surface cover
- Extensive vegetation on natural terrain above crest (i.e. constraint for cutting back the slope)
- Sparse self-seeded vegetation on existing slope
- Slope works associated with site formation for a proposed footbridge

Environmental Setting

- Exposed to sunlight (south-facing)
- Minimal potential shading problem (e.g. no significant overhanging trees)
- Urban road at slope toe

Stakeholders' Views

- Support for provision of screening planting
- Request to provide maintenance access and minimise future slope maintenance
- Need to support the adjacent ground

Landscape Concept

- Retain as much of the existing slope vegetation as possible
- Provide screen planting if possible
- Allow natural dispersal of adjacent species onto the upper slope portion

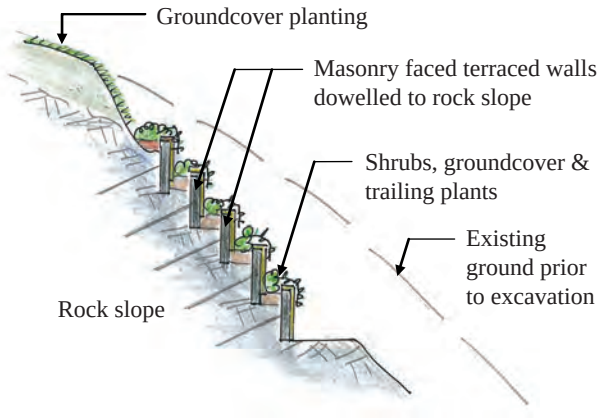
Slope Works and Landscaping Options

Option	Engineering Description (of selected option)	Landscape Considerations		
		Minimising Physical Impact	**Landscape Softworks**	**Landscape Hardworks**
1 Terraced walls (average slope angle of 65°) (✔)	• Rock dowels and soil nails • Concrete skin walls • Raking drains • Maintenance access	• Formation of a series of terraced walls to minimise the disturbance to existing vegetation	• Provide shrubs and climbers along the terraced walls • Provide grass cover to the upper portion	• Masonry facing to concrete skin walls
2 Rock cut	• Rock dowels and soil nails • Wire mesh netting and buttresses • Raking drains • Maintenance access	• Formation of a steep cut to minimise the extent of disturbance to existing vegetation	• Provide trees and groundcover vegetation in toe planter • Provide grass cover to the upper portion	• Masonry facing to toe planter and buttresses • Brown coloured PVC wire mesh

Example A5 **Sheet 2 of 2**

Option 1 is preferred because:

- *Maximising the opportunities for planting by forming a series of terraced walls*
- *Screening planting can be provided at planter*
- *Low life-cycle cost of the landscaping works*



Engineering and Landscape Works Implemented

- Rock dowels and soil nails
- Skin concrete walls with masonry facing
- Formation of a series of terraces for planting of shrubs and climbers
- Direct outlets of raking drains to water vegetation
- Provision of maintenance access

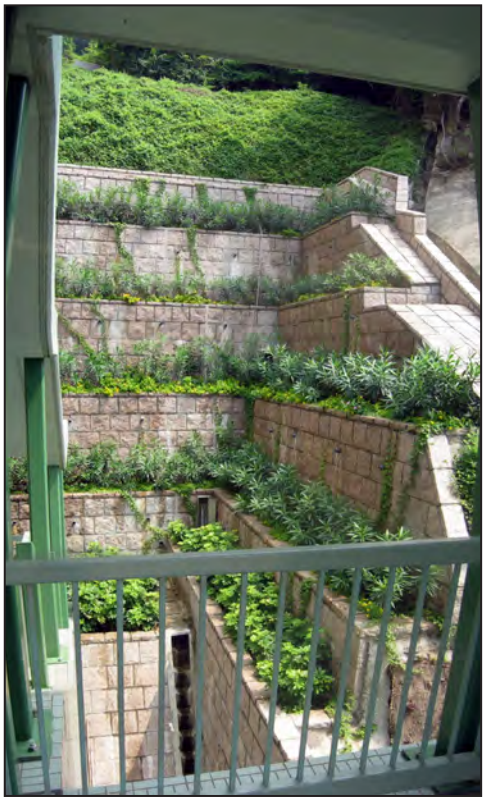
Construction Precautions

- Execute the engineering works carefully to avoid damage to existing vegetation

Maintenance and Sustainability

- Minimal maintenance required for planted vegetation

Completed Works



After establishment within terraced walls (2002)

Example A6 - Landscape Softworks to an Existing Rock Cut Slope (Roadside Environment) **Sheet 1 of 2**

Rock cut slope before upgrading works (2000)

Site Characteristic and Constraints
- 24 m high, 80° rock cut slope along urban roadside
- Existing sprayed concrete surface cover
- Extensive vegetation on natural terrain above crest (i.e. constraint for cutting back the slope)
- Sparse self-seeded vegetation on existing slope
- Reasonably wide footpath at toe (i.e. space available for planter)

Environmental Setting
- Exposed to sunlight (southwest-facing)
- Minimal potential shading problem (e.g. no significant overhanging trees)
- Urban road at slope toe; moderately trafficked; moderate wind effects or air pollution anticipated
- Adjacent woodland comprising exotic and native species including some small trees

Stakeholders' Views
- Support for provision of screening planting at toe
- Request to provide maintenance access and minimise future slope maintenance
- Footpath at toe to remain open during construction

Landscape Concept
- Retain as much of the existing slope vegetation as possible
- Provide screen planting at slope toe if possible
- Allow natural dispersal of adjacent species onto more weathered rock portions

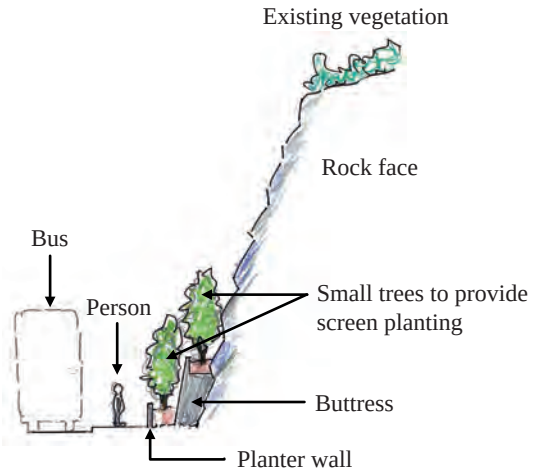
Slope Works and Landscaping Options

Option	Engineering Description (of selected option)	Landscape Considerations		
		Minimising Physical Impact	**Landscape Softworks**	**Landscape Hardworks**
1 Rock Slope Stabilisation Measures (RSSM) (✔)	• Rock bolts and dowels • Buttresses as necessary • Wire mesh as necessary • Dentition as necessary • Maintenance access	• Retain existing slope profile and majority of existing vegetation on slope • Avoid vegetation removal at crest for maintenance access	• Provide trees as screening vegetation in toe planter • Provide climbing and groundcover vegetation in toe planter	• Masonry facing to toe planter and buttresses • Grey coloured PVC wire mesh

Example A6 **Sheet 2 of 2**

Option 1 is proposed because:

- *No disturbance to vegetation at crest*
- *Screening planting can be provided at toe planter*
- *Low life-cycle cost of the landscaping works*



Engineering and Landscape Works Implemented

- Rock dowels and rock bolts
- Concrete buttresses with masonry facing
- Provision of wire mesh
- Toe planter wall with masonry facing, climbers and trees
- Painting of exposed engineering and slope furniture elements
- Provision of maintenance access

Construction Precautions

- Execute the engineering works carefully to avoid damage to the existing vegetation

Maintenance and Sustainability

- Watering may be necessary to support vegetation in planter during dry season

Completed Works

Recent photograph of slope appearance (2011)

Example A7 - Landscape Softworks to Flexible Barriers (Natural Hillside) **Sheet 1 of 2**

Typical view of natural terrain landslides

Site Characteristic and Constraints
- Steep terrain susceptible to natural hillside failures
- Surrounded by natural woodland with native and exotic species
- Road below the natural hillside
- Visually sensitive site, ecological assessment likely to be necessary
- No formed access available to potentially unstable hillside area

Environmental Setting
- Open hillside exposed to sun and wind
- Hillside is habitat for various fauna
- Rural location

Stakeholders' Views
- Minimise vegetation removal
- Minimise future maintenance
- Provide screening to the completed works

Landscape Concept
- Retain existing vegetation as far as practicable (i.e. minimise footprint of engineering works)
- Provide screen planting to engineering works

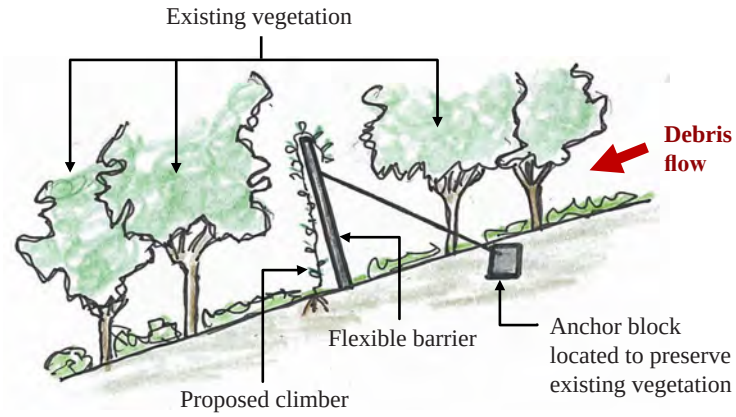
Slope Works and Landscaping Options

Option	Engineering Description (of selected option)	Landscape Considerations		
		Minimising Physical Impact	**Landscape Softworks**	**Landscape Hardworks**
1 Flexible barriers (✔)	• Construct flexible barriers • Provide maintenance access	• Minimise removal of vegetation at locations of flexible barriers and maintenance access road	• Ecological planting of trees and climbers in front of the flexible barriers and access road • Re-provide vegetation along temporary access	• Paint finish to exposed engineering elements
2 In-situ stabilisation works (e.g. soil nailing)	• Install soil nails • Provide maintenance access	• Considerable loss of existing vegetation and ecological habitats • Maintenance access could be extensive	• Re-vegetate disturbed areas with trees, shrubs and grass • Planting to screen maintenance access	

Example A7 **Sheet 2 of 2**

Option 1 is preferred because:

- *Low construction cost*
- *Least disturbance to existing vegetation*
- *Little disturbance to the natural hillside*
- *Minimise area of work sites*
- *Relatively low life-cycle cost of the landscaping works*



Necessary Construction Precautions

- Protect surrounding vegetation from construction impact and equipment
- Careful control of vegetation clearance for access and construction of flexible barriers as far as possible

Maintenance and Sustainability

- Screening vegetation requires minimal maintenance once established

Completed Works

Natural terrain mitigation works completed (vegetation is beginning to screen the flexible barriers and maintenance access)

Example (from overseas) of the use of multiple flexible barriers within drainage channels

Example A8 - Landscape Softworks to Debris Resisting Barriers (Natural Hillside) **Sheet 1 of 2**

Typical debris trails on natural hillside

Site Characteristic and Constraints

- Steep natural hillside
- Distinct debris flowpath trails
- Natural woodland on hillside
- Major road below hillside, likely to be within debris flow runout zone
- Sensitive site, adjacent to Country Park (i.e. ecological assessment needed)
- Site is highly visible from adjacent residential towers

Environmental Setting

- Open hillside exposed to sun and wind
- Existing woodland including native and exotic species
- Hillside is habitat for various fauna
- Rural location (outlying island)

Stakeholders' Views

- Minimise vegetation removal
- Minimise future maintenance
- Provide screening to works from view of adjacent residential buildings

Landscape Concept

- Retain existing vegetation as far as practicable
- Landscape treatment to the debris resisting barrier and the associated slope furniture

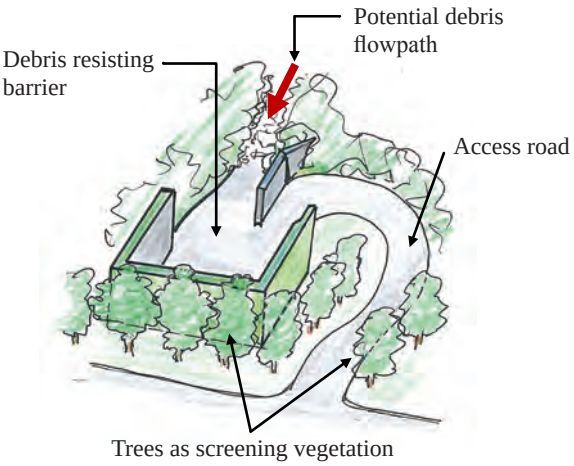
Slope Works and Landscaping Options

Option	Engineering Description (of selected option)	Landscape Considerations		
		Minimising Physical Impact	**Landscape Softworks**	**Landscape Hardworks**
1 Rigid barrier at deposition zone (✔)	• Construct concrete debris resisting barrier • Provide maintenance access	• Loss of vegetation at locations of rigid barrier and the associated access road, both at bottom of the hillside	• Trees in front of structure to provide screening • Provide fill embankment against sides of structure for planting • Provide planters at top of walls for hanging plants	• Paint finish to exposed engineering elements and slope furniture
2 In-situ stabilisation and flexible barriers	• Install soil nails and construct flexible barriers • Provide maintenance access	• Loss of existing vegetation for construction of soil nails, flexible barriers and maintenance access • Maintenance access could be extensive	• Planting around sides of barriers to partially screen (rocky nature of flowpath inhibits substantial planting) • Plant trees to screen maintenance access	

Example A8 **Sheet 2 of 2**

Option 1 is preferred because:

- *Minimum disturbance to the natural hillside*
- *Easier to maintain*
- *More certainty in engineering function (i.e. in containing debris)*
- *Relatively low life-cycle cost of the landscaping works*



Construction Precautions

- Protect surrounding vegetation from construction impact, dust, material spillages, etc.
- Minimise vegetation clearance (i.e. on-site review of best location and orientation to serve engineering and vegetation retention functions)

Maintenance and Sustainability

- Minimal maintenance for screening vegetation
- Hanging plants may need replacement if they do not receive adequate dry season watering
- In the event of a debris flow, life-cycle cost should allow for debris removal and possibly repair of damage to structure and vegetation

Vision of the Completed Works

Photomontage showing an aerial view of the completed works

Appendix B

Illustrations of Landscape Softworks

Before slope upgrading works

1 year after slope works with hydroseeding and pit planting of native species seedlings

5 years after slope works

Illustrations of successful establishment of native plant species and natural dispersal of vegetation over time along Clear Water Bay Road

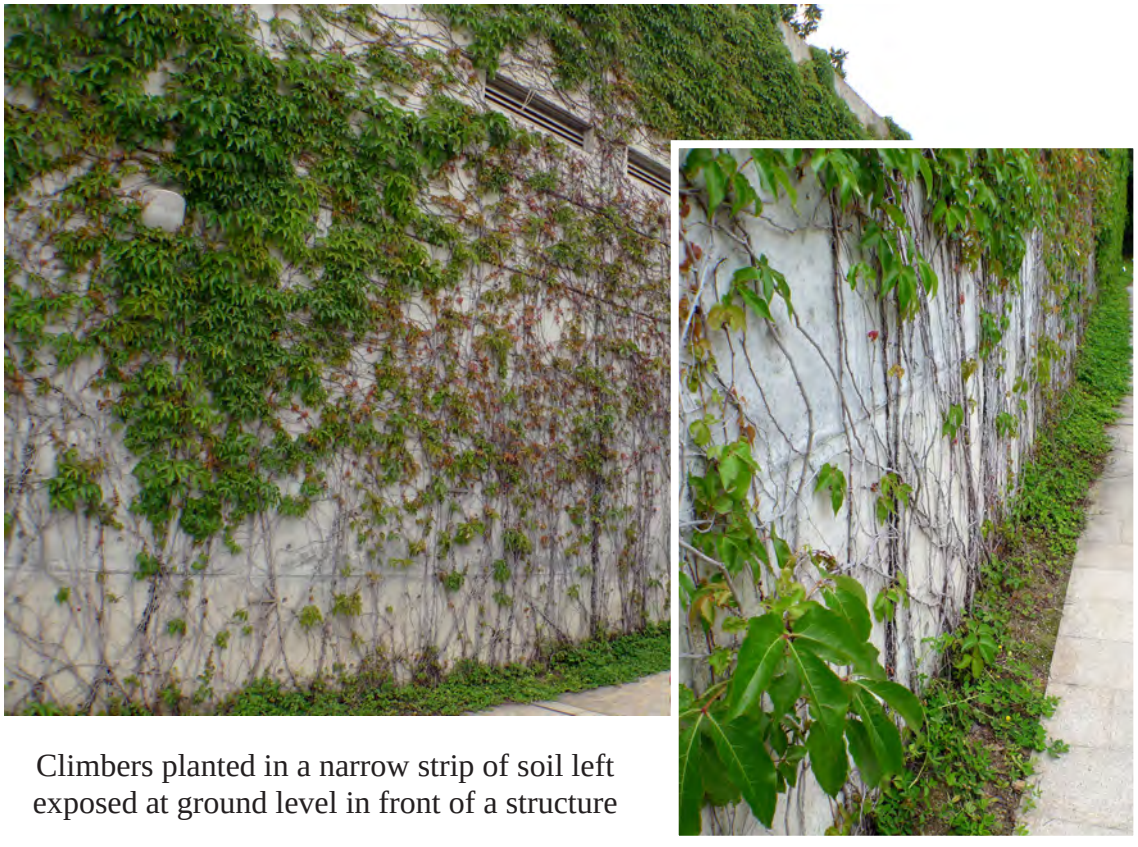
Wildlife observed during site survey after slope works

Illustration of landscaping to man-made slopes along South Lantau Road to improve visual appearance, as well as enhance ecological value by planting native species

Existing trees and new planting on roadside slope

Creation of indented space for tree planting at the slope toe (adequate space should be provided to allow chosen tree species to grow)

Ferns and flowering shrubs on a
steep soil nailed roadside cut slope



Climbers planted in a narrow strip of soil left
exposed at ground level in front of a structure

Ferns and other shade tolerant species under tree cover on a soil nailed fill slope

Grass and shrubs on a fill slope planted over a buried soil nail concrete grillage system

General illustrations of the use of toe planters to support planting

Cut slope planted with trees in a toe planter and
access path contoured to reduce visual impact

Slope upgrading works in progress in 1986

A view of the slope in 2001

Successful establishment of vegetation on a soil fill slope

Planting on hard surfacing using proprietary mulching system on a steep cut slope

Wedelia trilobata growing in mulching panels on a hard surface

Just after planting

1 year after planting

Groundcover vegetation developing on a soil nailed slope where notch planting was used in lieu of hydroseeding (soil nail heads are covered with soil bags and degradable erosion control mat)

Climbers developing along the wire mesh as a trellis on a mixed soil and rock cut slope

A vegetated cut slope with retaining wall at the toe (vegetation in a crest planter trailing down the wall)

Climbers growing on a buttress wall

Well established hydroseeded grass on a rockfill slope
with soil cement mix overlay

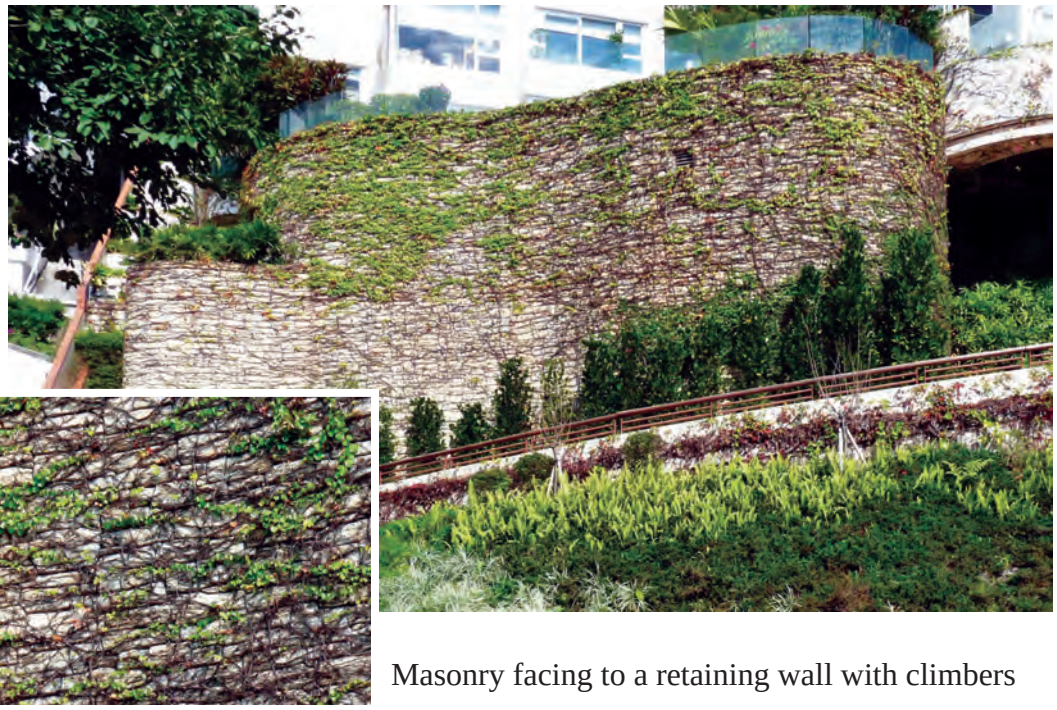
Planting supported by facing panels
on a reinforced fill structure

Ornamental planting

Appendix C

Illustrations of Landscape Hardworks

Masonry faced buttresses and ribbed finish to a concrete wall

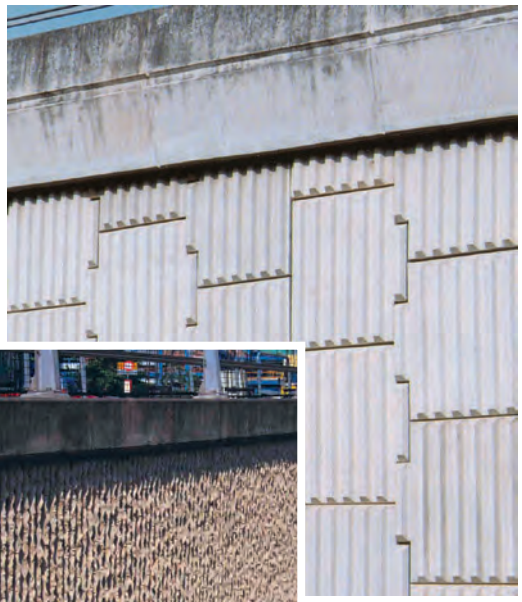


Masonry facing to a retaining wall with climbers

Stone pattern precast concrete panels used as permanent formwork for a concrete wall

Coloured masonry facing to a skin wall (the pattern of masonry blocks followed the existing wall and the block size decreases with height)

Off-formwork graphic pattern finish to RC retaining walls



Commonly used ribbed finish

Artificial rock blocks incorporated into masonry surface finish

Masonry facing to buttresses and toe planter for rock slope (screen planting further softens the appearance of visually sensitive area at the lower portion of the slope)

Masonry planter wall, coloured handrails and sprayed concrete hard surface to upper slope

Painted slope hard surfacing further screened by planting in toe planters

Use of a spray applied coloured masonry like finish to a hard surface

Provision of tree rings to retain existing trees and use of limited available space for planters (planting climbers to reduce visual impact of a hard surface)

Planting of climbers in a toe planter to minimise the visual impact of a hard slope surface

Coloured buttress and hard slope surface with planting at various levels

Wire mesh as a trellis for climbers to reduce the visual impact of a rock slope

Climbers and screen planting at the toe to soften the appearance
of a concrete retaining wall

Handrails of reduced sizes and coloured to suit the site conditions

Use of stone staircase to blend in with the natural environment

Access to maintenance stairways serving two slopes discretely placed through planter

Soil nail heads encased in an irregular grillage structure for retention of exiting vegetation

Use of patterned beams to create visual interest

Exposed stonework appearance by the use of gabion walls

Tree retention in combination with hard landscape finish

Use of patterned masonry blocks

Preservation of wall trees on an old masonry wall with provision of skin wall with space left to accommodate the existing wall trees

Openings in a soil nailed fill slope using grillage system to retain the existing trees (grillage covered in masonry facing)

Soil nail heads located beneath granite finish textured blocks
on an old masonry wall with existing wall trees

Soil nail heads well covered by stone pitching

Appendix D

Checklist of Landscape Design Considerations

Design Issue	Consideration
Site setting	Slope type • cut, fill, retaining wall, natural terrain
	Likely ground and soil conditions • soil, rock, likely weathering grade, etc. • presence of groundwater
	Gradients and orientation • cut, fill, retaining wall, natural terrain
	Slope type • blending in with surrounding topography • proportioning of berm height • opportunities for rounding transition between new and existing slopes • opportunities for use of sloping berms • potential for terracing
	Existing drainage lines • natural, man-made, location and size
	Signs of erosion or slope distress • location, extent, likely contributing factors, need for particular erosion control
	Existing surface cover • vegetation or hard cover • characteristic of existing masonry blocks (e.g. size, colour, pattern) • physical and visual impact
Environmental setting	Existing trees and vegetation • tree survey, vegetation surveys • opportunities to retain existing healthy trees • protection of ecologically important flora and habitats • need for tree felling and/or transplanting • need for tree protection
	Site location • urban, rural, heritage sites, water gathering grounds, Country Park and other environmentally sensitive areas such as site of special scientific interest (SSSI), conservation area, etc.
	Surrounding elements • full vegetation, buildings/structures, roads, etc. • shading and sunlight • presence of overhanging trees providing shading • exposure to wind and pollution, including that generated by traffic • exposure to sunlight (e.g. south-facing)
	Ecology • ecological surveys • presence of birds, insects and animals • presence of ecologically important species and habitats • opportunities to enhance ecological value
Site-specific constraints	• stakeholders' wishes • loading from mature trees on retaining walls • buildings/structures on or adjacent to site • utilities • interfaces with other projects • district Greening Master Plans (GMP), EIA and/or other Ordinance requirements • physical and visual impact of likely engineering works

Design Issue	Consideration
Planting opportunities	Planting • planting on the slope face, in berms, at the toe or crest planters and in adjacent areas to provide screening • limitations on planting imposed by operational requirements • requirements for plant growth • soil pockets in hard surface cover to rock faces, crib walls, grillages, gabions, etc. • for thin soils, grass, groundcover, climbers or shrubs • creeping groundcover are suitable for mixed soil and rock slopes • deeper soil pockets for large shrubs and trees • need for surface erosion control (e.g. matting, hard surfacing)
	Sustainability • aim for low maintenance needs • use of pioneer species for rapid greening • use of native or exotic species • encourage dispersal of adjacent species to provide mature woodland
Visual treatment of engineering elements and slope furniture and associated landscape hardworks	Concrete drainage channels, catchpits, berms and concrete access stairways • number and extent • located away from visually prominent areas • adopt naturalistic alignments • recess into slope surface • located to avoid existing vegetation and tree roots • surface treatment (e.g. painting) • co-ordinate with landscape treatment
	Soil nail heads, concrete grillages and rock bolt heads • position - avoid existing vegetation and tree roots • arrangement, grouping and orientation • size and shape • buried or exposed • colour and surface treatment
	Rock finishes • blasted or mechanically formed rock faces • berm planting • wire mesh netting - colour
	Buttresses, retaining walls, planter walls, debris barriers, check dams, etc. • shape and inclination • scale and proportion • co-ordination with other elements • retain existing vegetation • climbing, hanging and/or screening vegetation • coping features • surface finishes
	Sprayed concrete • colour • artistic designs • planter holes • tree rings - arrangement and size • climbing plants
	Masonry facing • scale and proportion • patterns, textures, colour, material finishes • fit with surrounding/existing masonry facing/rock • co-ordination with engineering design

Design Issue	Consideration
Visual treatment of engineering elements and slope furniture and associated landscape hardworks	Reinforced fill structures • benching and terracing • planting opportunities • surface finishes
	Metal handrailing and metal stairways and slope signage plates • painting to minimise visual appearance • minimise number/extent required • located in discrete areas • co-ordinate placement with proposed landscaping
Planting design	Soil requirements Depth necessary for various species • retention and re-use of existing topsoil Topsoiling or other ameroliation • soil quality and amelioration • soil quantity and depth
	Planting considerations • nature of soil (e.g. weathering grade, presence of topsoil) • mixed soil and rock slopes
	Plant species selection • size of trees (e.g. use light standard trees[1] on slopes) • plant species characteristics (e.g. tolerance to exposure, shade, dry season conditions, etc.) • ecological context and sustainability – use of native species
Implementation	General Requirements • supervision of planting works and tree protection • supervision of hard surface finishes (e.g. trial panels) • need for contractors' method statements • need for specialist advice
	Establishment Period • replacement of dead plants • grass cutting, watering, removal of weeds and invasive species • clearance of non-organic litter on soft landscape, and clearance of litter on hard landscape • application of fertilizer, securing of any stakes and ties, etc. • frequency of operations • handover to maintenance agents
Maintenance	General requirements • co-ordination with maintenance agents • safe access • irrigation water supply
	Long-term maintenance • regular inspection of planting • selective thinning and/or enhancement of species • removal of invasive species • clearance of vegetation for inspection of engineering elements • maintenance manual

[1] As defined in the GS

Appendix E

Plant Selection

E.1 Introduction

Planting the right plant species at the right place is essential to achieve sustainability. This Appendix provides general guidance on plant selection for slope works and should be read in conjunction with the general recommendations for planting and erosion control by slope gradient given in Figure 2.15 and Table 2.2. Tables E1 to E7 are lists of recommended species under various typical slope settings and gradients. These lists were generated from a comprehensive literature review of previous recorded slope planting experience in Hong Kong. Species that were found successful from the review were recommended.

The *Field Guide to Trees in Hong Kong's Countryside* (AFCD, 2008a) provides photographic illustrations and information for many of the tree species in Tables E1 to E7. In addition, the *Flora of Hong Kong* (AFCD, 2007; 2008b; 2009 & 2011) also provides comprehensive botanical information of the recommended species. All plant names in this Appendix follow the Hong Kong Plant Database of the Hong Kong Herbarium of Agriculture, Fisheries and Conservation Department (http://www.hkherbarium.net/Herbarium/frame.html), which is supplemented by the Flora of China database (http://www.efloras.org/index.aspx).

The essentials for healthy plant growth and site characteristics that affect plant growth are summarised in Tables E8 and E9, respectively.

E.2 Suggested Methodology of Plant Selection for Slope Works

The planting goals should be determined at the early planning stage considering the environmental settings as well as engineering solutions. Basically, all slope planting should aim primarily to provide surface erosion control as well as greening effect. Ecological improvement should be considered where practicable.

E.2.1 Steep Slopes

For steep slopes (>45°, Figure 2.15 and Table 2.2), the planting goal is simply to provide ground covering vegetation for surface erosion control and greening rather than ecological improvement. With considerations of tree hazard and public safety, the species recommended are the common herbaceous and climber species that have been used widely on steep slopes in Hong Kong (Table E1).

Table E1 Recommended Plant Species for Groundcover Vegetation on Steep Slopes (>45°) in Hong Kong

Scientific name	Common name	Chinese name	Origin	Growth habit
Axonopus compressus	Carpet Grass	地毯草	Exotic	Herb (grass)
Cenchrus echinatus [1]	Bur Grass	蒺藜草	Exotic	Herb (grass)
Chloris gayana [1]	Rhodes-grass	非洲虎尾草	Exotic	Herb (grass)
Cynodon dactylon [1]	Couch Grass	狗牙根	Native	Herb (grass)
Eragrostis curvula [1]	Oulandgrass	彎葉畫眉草	Native	Herb (grass)
Eremochloa ophiuroides	Smooth Lawn Grass	假儉草	Native	Herb (grass)
Ficus pumila	Creeping Fig	薜荔	Native	Climber
Lantana montevidensis	Trailing Lantana	小葉馬纓丹	Exotic	Shrub
Lolium perenne [1]	Perennial Ryegrass	黑麥草	Exotic	Herb (grass)
Parthenocissus dalzielii	Diverse-leaved Creeper	異葉爬牆虎	Exotic	Climber
Paspalum notatum	Bahiagrass	百喜草	Exotic	Herb (grass)
Zoysia japonica	Korean Lawngrass	結縷草	Exotic	Herb (grass)
Zoysia matrella	Manila Grass	溝葉結縷草	Native	Herb (grass)

[1] Grass species included in standard hydroseeding mix in the GS.

E.2.2 Moderately Steep Slopes

For moderately steep slopes (35° - 45°, Figure 2.15 and Table 2.2), the planting goal is to provide ground covering vegetation for surface erosion control and greening, with ecological improvement as applicable whereby suitable shrubs may be planted. Therefore, the species recommended are the common shrub, herbaceous and climber species that have been used widely on moderately steep slopes in Hong Kong (Table E2).

Table E2 Recommended Plant Species for Moderately Steep Slopes (35° - 45°) in Hong Kong

Scientific name	Common name	Chinese name	Origin	Growth habit
Ardisia crenata	Hilo Holly	朱砂根	Native	Shrub
Axonopus compressus	Carpet Grass	地毯草	Exotic	Herb (grass)
Cenchrus echinatus [1]	Bur Grass	蒺藜草	Exotic	Herb (grass)
Chloris gayana [1]	Rhodes-grass	非洲虎尾草	Exotic	Herb (grass)
Chrysalidocarpus lutescens	Bamboo Palm	散尾葵	Exotic	Shrub
Cordyline fruticosa	Iron Plant, Tree of King	朱蕉	Exotic	Shrub
Cynodon dactylon [1]	Couch Grass	狗牙根	Native	Herb (grass)
Diplospora dubia	Common Tricalysia	狗骨柴	Native	Shrub
Eragrostis curvula [1]	Oulandgrass	彎葉畫眉草	Native	Herb (grass)
Eremochloa ophiuroides	Smooth Lawn Grass	假儉草	Native	Herb (grass)
Ficus pumila	Creeping Fig	薜荔	Native	Climber
Gardenia jasminoides	Cape Jasmine	梔子	Native	Shrub
Lantana montevidensis	Trailing Lantana	小葉馬纓丹	Exotic	Shrub
Ligustrum sinense	Chinese Privet	山指甲	Native	Shrub
Litsea rotundifolia var. *oblongifolia*	Oblong-leaved Litsea	豺皮樟	Native	Shrub
Lolium perenne [1]	Perennial Ryegrass	黑麥草	Exotic	Herb (grass)
Melastoma malabathricum [2]	Common Melastoma	野牡丹	Native	Shrub
Melastoma sanguineum	Blood-red Melastoma	毛蕊	Native	Shrub
Parthenocissus dalzielii	Diverse-leaved Creeper	異葉爬牆虎	Exotic	Climber
Paspalum notatum	Bahiagrass	百喜草	Exotic	Herb (grass)
Pittosporum tobira	Pittosporum	海桐	Exotic	Shrub
Psychotria asiatica	Wild Coffee	九節	Native	Shrub
Rhapis excelsa	Lady Palm	棕竹	Native	Shrub
Rhaphiolepis indica	Hong Kong Hawthorn	石斑木	Native	Shrub
Rhododendron simsii	Red Azalea	紅杜鵑	Native	Shrub
Rhodomyrtus tomentosa	Rose Myrtle	桃金娘	Native	Shrub
Zoysia japonica	Korean Lawngrass	結縷草	Exotic	Herb (grass)
Zoysia matrella	Manila Grass	溝葉結縷草	Native	Herb (grass)

[1] Typical grass species included in the hydroseeding mix in Hong Kong according to the GS.
[2] According to the *Flora of Hong Kong*, *Melastoma candidum* is now a synonym of *Melastoma malabathricum*.

E.2.3 Gentle Slopes and Natural Terrain Landslide Scars

For gentle slopes (<35°, Figure 2.15 and Table 2.2) and natural terrain landslide repairs, more complex and long lasting vegetation, such as shrubs and trees, should be planted (Tables E3 to E7). Whilst the general recommendation is to plant only small trees on slopes, and only for slopes up to 35°, some medium and large tree species are included herein. These might be considered for planting on gentler areas of slopes (e.g. less than 15°) or as screen planting along roadside verges or in toe planters. However, in such cases due consideration

must be given to long-term safety aspects relating to the stability of such trees (e.g. likely exposure to wind in the proposed setting).

There are opportunities for enhancing ecological conditions of a site, however, the location of the slope is important in deciding whether ecological planting should be adopted. Hydroseeding of typical grass mix is still required in all cases to provide a rapid surface erosion control cover in order to allow time for shrubs and trees to establish. The hydroseeded grass cover will gradually be suppressed by the shrub and tree canopies formed. Natural succession may bring in other ground covering herbaceous species that can withstand the canopy shade. Therefore, no herbaceous species are included in Tables E3 to E7 except for ornamental planting.

Pit planting of container-grown seedlings is the most effective planting method for planting shrubs and trees. Although planting stem-cuttings and direct-seeding have been tried in previous studies, more field data are needed to confirm the effectiveness of these application methods.

Tree species in Tables E3 to E7 are categorised with respect to their normal sizes in the wild in Hong Kong (DEVB, 2010b):

- Large tree is normally taller than 10 m with a large crown
- Medium tree is much taller than 3 m but with a small crown
- Small tree is normally around 3 m in height

The planting goal for gentle slopes and natural terrain landslide repairs (Figure E1) can be broadly classified into:

(a) Ecological planting - aims to create a vegetation cover that will gradually integrate with the surrounding natural vegetation. Mostly native tree and shrub species are recommended to maximise the ecological benefit (Tables E3, E4 and E7). No additional maintenance requirements to the standard practice of slope maintenance are needed for ecological planting.

(b) Amenity planting - aims for basic landscape enhancement at locations where ecological planting is not feasible. The recommended species include both native and exotic shrub and tree species (Table E5). Similar to ecological planting, no additional maintenance requirements are needed for amenity planting.

(c) Ornamental Planting - aims for strong emphasis on ornamental effect, i.e. planting species with colourful flowers and foliage (Table E6). Relatively intensive and regular maintenance including watering, weeding, fertilisation and pruning would be needed, in addition to the standard practice on slope maintenance. Therefore, ornamental planting is only recommended for sites in

visually sensitive areas, such as parks and gardens, where sufficient resources are available. It may also be applied to planters subject to the agreement of the maintenance agents.

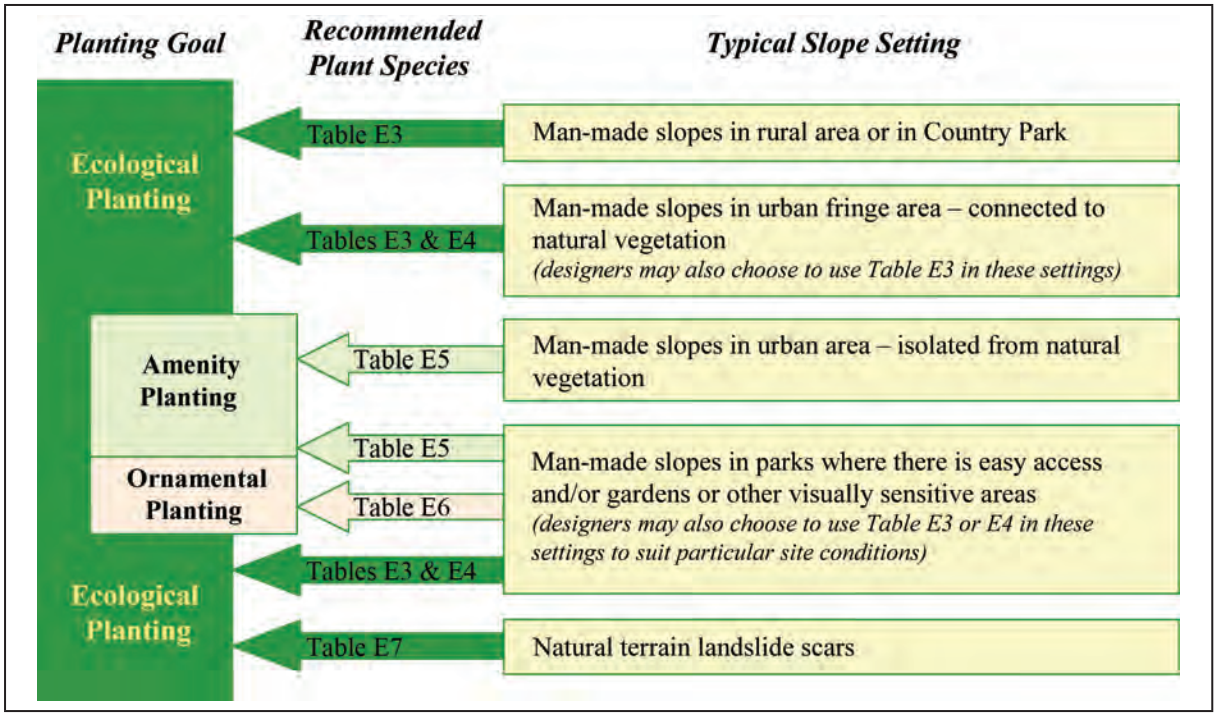


Figure E1 Suggested Methodology of Plant Selection for Gentle Slopes (<35°) and Natural Terrain Landslide Repairs

Table E3 Recommended Plant Species for Ecological Planting on Man-made Slopes in Rural Areas or Country Park
(All species are native to Hong Kong which can maximise the ecological benefit)

Scientific name	Common name	Chinese name
Growth form: Shrub		
Ardisia crenata	Hilo Holly	朱砂根
Diplospora dubia	Common Tricalysia	狗骨柴
Gardenia jasminoides	Cape Jasmine	梔子
Ligustrum sinense	Chinese Privet	山指甲
Litsea rotundifolia var. *oblongifolia*	Oblong-leaved Litsea	豺皮樟
Melastoma malabathricum [1]	Common Melastoma	野牡丹
Melastoma sanguineum	Blood-red Melastoma	毛蕊
Psychotria asiatica	Wild Coffee	九節
Rhaphiolepis indica	Hong Kong Hawthorn	石斑木
Rhodomyrtus tomentosa	Rose Myrtle	桃金娘
Growth form: Small Tree [2]		
Cyclobalanopsis championii	Champion's Oak	嶺南青岡
Cyclobalanopsis myrsinifolia	Small-leaved Oak	小葉青岡
Elaeocarpus chinensis	Chinese Elaeocarpus	中華杜英
Ficus hispida	Opposite-leaved Fig	對葉榕
Ilex viridis	Small-leaved Holly	綠冬青
Melicope pteleifolia	Thin Evodia	三椏苦
Ormosia emarginata	Emarginate-leaved Ormosia	凹葉紅豆
Pyrus calleryana	Callery Pear	豆梨
Reevesia thyrsoidea	Reevesia	梭羅樹
Ternstroemia gymnanthera	Naked Anther Ternstroemia	厚皮香
Zanthoxylum avicennae	Prickly Ash	簕欓
Growth form: Medium Tree [2]		
Alangium chinense	Chinese Alangium	八角楓
Aporusa dioica	Aporusa	銀柴
Cinnamomum burmannii	Batavia Cinnamon, Cinnamon Tree	陰香
Cyclobalanopsis neglecta	Bamboo-leaved Oak	竹葉青岡
Diospyros morrisiana	Morris's Persimmon	羅浮柿
Garcinia oblongifolia	Lingnan Garcinia	嶺南山竹子
Litsea glutinosa	Pond Spice	潺槁樹
Machilus breviflora	Short-flowered Machilus	短序潤楠
Myrica rubra	Strawberry Tree	楊梅
Ormosia semicastrata	Soft-fruited Ormosia	軟莢紅豆
Schefflera heptaphylla	Ivy Tree	鵝掌柴
Syzygium levinei	Levine's Syzygium	山蒲桃
Tutcheria spectabilis	Common Tutcheria	石筆木
Viburnum odoratissimum	Sweet Viburnum	珊瑚樹
Growth form: Large Tree [2]		
Castanopsis fissa	Castanopsis	鼠刺錐
Choerospondias axillaris	Hog Plum	南酸棗
Lithocarpus harlandii	Harland's Tanbark	港柯
Schima superba	Schima	木荷
Syzygium hancei	Hance's Syzygium	韓氏蒲桃

[1] According to the *Flora of Hong Kong*, *Melastoma candidum* is now a synonym of *Melastoma malabathricum*.
[2] Large tree is normally taller than 10 m with a large crown. Medium tree is much taller than 3 m but with a small crown. Small tree is normally around 3 m in height (DEVB, 2010b).

Table E4 Recommended Plant Species for Ecological Planting in Urban Fringe Areas that are not Isolated from Natural Vegetation

(All species are native to Hong Kong which can maximise the ecological benefit)

Scientific name	Common name	Chinese name
Growth form: Shrub		
Diplospora dubia	Common Tricalysia	狗骨柴
Gardenia jasminoides	Cape Jasmine	梔子
Ligustrum sinense	Chinese Privet	山指甲
Litsea rotundifolia var. *oblongifolia*	Oblong-leaved Litsea	豺皮樟
Melastoma malabathricum [1]	Common Melastoma	野牡丹
Melastoma sanguineum	Blood-red Melastoma	毛蕊
Psychotria asiatica	Wild Coffee	九節
Rhaphiolepis indica	Hong Kong Hawthorn	石斑木
Rhododendron simsii	Red Azalea	紅杜鵑
Rhodomyrtus tomentosa	Rose Myrtle	桃金娘
Growth form: Small Tree [2]		
Bridelia tomentosa	Pop-gun Seed	土蜜樹
Cyclobalanopsis championii	Champion's Oak	嶺南青岡
Cyclobalanopsis myrsinifolia	Small-leaved Oak	小葉青岡
Mallotus apelta	White-back Leaf Mallotus	白背葉
Phyllanthus emblica	Myrobalan	餘甘子
Polyspora axillaris [3]	Hong Kong Gordonia	大頭茶
Reevesia thyrsoidea	Reevesia	梭羅樹
Rhus succedanea	Wax Tree	木蠟樹
Zanthoxylum avicennae	Prickly Ash	簕欓
Growth form: Medium Tree [2]		
Cyclobalanopsis neglecta	Bamboo-leaved Oak	竹葉青岡
Litsea glutinosa	Pond Spice	潺槁樹
Mallotus paniculatus	Turn-in-the-wind	白楸
Sapium discolor	Mountain Tallow Tree	山烏桕
Schefflera heptaphylla	Ivy Tree	鵝掌柴

[1] According to the *Flora of Hong Kong*, *Melastoma candidum* is now a synonym of *Melastoma malabathricum*.

[2] Medium tree is much taller than 3 m but with a small crown. Small tree is normally around 3 m in height (DEVB, 2010b).

[3] According to the *Flora of Hong Kong*, *Gordonia axillaris* is now a synonym of *Polyspora axillaris*.

Table E5 Recommended Plant Species for Amenity Planting
(Typically for man-made slopes in urban areas that are isolated from natural vegetation)

Scientific name	Common name	Chinese name	Origin
Growth form: Shrub			
Calliandra haematocephala	Pink Powder Puff	朱纓花	Exotic
Chrysalidocarpus lutescens	Bamboo Palm	散尾葵	Exotic
Cordyline fruticosa	Iron Plant , Tree of King	朱蕉	Exotic
Ligustrum sinense	Chinese Privet	山指甲	Native
Melastoma sanguineum	Blood-red Melastoma	毛菵	Native
Psychotria asiatica	Wild Coffee	九節	Native
Rhaphiolepis indica	Hong Kong Hawthorn	石斑木	Native
Rhapis excelsa	Lady Palm	棕竹	Native
Rhododendron simsii	Red Azalea	紅杜鵑	Native
Growth form: Small Tree [1]			
Bridelia tomentosa	Pop-gun Seed	土蜜樹	Native
Caryota mitis	Small Fishtail Palm	短穗魚尾葵	Exotic
Ficus hispida	Opposite-leaved Fig	對葉榕	Native
Polyspora axillaris [2]	Hong Kong Gordonia	大頭茶	Native
Reevesia thyrsoidea	Reevesia	梭羅樹	Native
Growth form: Medium Tree [1]			
Acacia auriculiformis	Ear-leaved Acacia	耳果相思	Exotic
Bauhinia variegata	Camel's Foot Tree	宮粉羊蹄甲	Exotic
Litsea glutinosa	Pond Spice	潺槁樹	Native
Macaranga tanarius	Elephant's Ear	血桐	Native
Mallotus paniculatus	Turn-in-the-wind	白楸	Native
Melia azedarach	China-berry	楝	Exotic
Phoenix hanceana	Spiny Date Palm	刺葵	Native
Schefflera heptaphylla	Ivy Tree	鵝掌柴	Native
Growth form: Large Tree [1]			
Cassia siamea	Kassod Tree	鐵刀木	Exotic

[1] Large tree is normally taller than 10 m with a large crown. Medium tree is much taller than 3 m but with a small crown. Small tree is normally around 3 m in height (DEVB, 2010b).

[2] According to the *Flora of Hong Kong*, *Gordonia axillaris* is now a synonym of *Polyspora axillaris*.

Table E6 Recommended Species for Ornamental Planting on Man-made Slopes
(Regular maintenance including weeding, pruning, watering and fertiliser application are required to maintain the visual attractiveness of the planted vegetation)

Scientific name	Common name	Chinese name	Origin	Growth habit [1]
Aglaia odorata	Mock Lime	米仔蘭	Exotic	Shrub
Alocasia macrorrhiza	Giant Alocasia	海芋	Exotic	Herb
Bambusa tuldoides	Verdant Bamboo	花眉竹	Native	Shrub
Bauhinia purpurea	Purple Camel's Foot	紅花羊蹄甲	Exotic	Medium Tree
Bauhinia variegata	Camel's Foot Tree	宮粉羊蹄甲	Exotic	Medium Tree
Bougainvillea spectabilis	Beautiful Bougainvillea	葉子花	Exotic	Climber
Calliandra haematocephala	Pink Powder Puff	朱纓花	Exotic	Shrub
Caryota mitis	Small Fishtail Palm	短穗魚尾葵	Exotic	Small Tree
Cassia siamea	Kassod Tree	鐵刀木	Exotic	Large Tree
Chrysalidocarpus lutescens	Bamboo Palm	散尾葵	Exotic	Shrub
Cordyline fruticosa	Iron Plant, Tree of King	朱蕉	Exotic	Shrub
Duranta erecta	Golden Dewdrops	假連翹	Exotic	Climber
Ficus pumila	Creeping Fig	薜荔	Native	Climber
Hedera helix	Ivy	洋常春藤	Exotic	Climber
Hibiscus rosa-sinensis	Chinese Hibiscus	朱槿(大紅花)	Exotic	Shrub
Ixora chinensis	Chinese Ixora	龍船花	Native	Shrub
Lantana montevidensis	Trailing Lantana	小葉馬纓丹	Exotic	Shrub
Ligustrum sinense	Chinese Privet	山指甲	Native	Shrub
Parthenocissus dalzielii	Diverse-leaved Creeper	異葉爬牆虎	Exotic	Climber
Paspalum notatum	Bahiagrass	百喜草	Exotic	Herb (grass)
Phoenix hanceana	Spiny Date Palm	刺葵	Native	Medium Tree
Rhapis excelsa	Lady Palm	棕竹	Native	Shrub
Rhododendron mucronatum	White Azalea	白杜鵑	Exotic	Shrub
Rhododendron pulchrum	Lovely Azalea	錦繡杜鵑	Exotic	Shrub
Rhododendron pulchrum var. *phoeniceum*	Purple Azalea	紫杜鵑花	Exotic	Shrub
Rhododendron simsii	Red Azalea	紅杜鵑	Native	Shrub
Washingtonia robusta	Petticoat Palm	華盛頓葵	Exotic	Small Tree

[1] Large tree is normally taller than 10 m with a large crown. Medium tree is much taller than 3 m but with a small crown. Small tree is normally around 3 m in height (DEVB, 2010b).

Table E7 Recommended Native Plant Species for Natural Terrain Landslide Repairs
(This recommended list is based on common native plant species recorded along landslide trails. No field trials have been done)

Scientific name	Common name	Chinese name	Growth habit [1]
Blechnum orientale	Oriental Blechnum	烏毛蕨	Herb (Fern)
Cratoxylum cochinchinense	Yellow Cow Wood	黃牛木	Small Tree
Dicranopteris pedata	Dichotomy Forked Fern	芒萁	Herb (Fern)
Embelia ribes	White-flowered Embelia	白花酸藤子	Climber
Litsea rotundifolia var. *oblongifolia*	Oblong-leaved Litsea	豺皮樟	Shrub
Mallotus paniculatus	Turn-in-the-wind	白楸	Medium Tree
Melastoma malabathricum [2]	Common Melastoma	野牡丹	Shrub
Melastoma sanguineum	Blood-red Melastoma	毛蒽	Shrub
Rhaphiolepis indica	Hong Kong Hawthorn	石斑木	Shrub
Sapium discolor	Mountain Tallow Tree	山烏桕	Medium Tree
Smilax glabra	Glabrous Greenbrier	土茯苓	Climber

[1] Large tree is normally taller than 10 m with a large crown. Medium tree is much taller than 3 m but with a small crown. Small tree is normally around 3 m in height (DEVB, 2010b).
[2] According to the *Flora of Hong Kong*, *Melastoma candidum* is now a synonym of *Melastoma malabathricum*.

E.3 Notes on Planting Applications

The establishment and growth of plant communities on slopes are subject to a large number of inter-related variables (Table E8).

As a guide, the potential effects of the characteristics of a site on plant growth are summarised in Table E9.

Table E8 Essentials for Healthy Plant Growth

Requirement	Consideration
Soil	A sufficient volume of free draining organic soil to allow root development and support, and the supply of water and nutrients
Air	Shelter from wind and a location free from pollution (e.g. road traffic)
Water	To be supplied either by natural groundwater, rain or irrigation
Sunlight	Sufficient sunlight and/or absence of shade unless shade tolerant species are used

Table E9 Site Characteristics Affecting Plant Growth

Requirement	Characteristic	Effect
Soil	• physical composition	• soil thickness and stiffness (see Section 2.3.3)
		• water-holding capacity
		• availability of oxygen (air pockets in soil) and ability of plants to take up oxygen through their roots
	• chemical composition	• nutrient availability
	• pH and salinity	• nutrient uptake
Sunlight	• sunlight and shading	• sunlight requirements for photosynthesis
Air	• wind	• the rate at which plants lose water through their leaves (evapo-transpiration)
	• exposure	• the rate at which plants lose water through their leaves (evapo-transpiration)
	• quality	• plant health - particularly under the effects of particulate and chemical pollution

The requirements for healthy growth differ greatly from one species to another. Most plants prefer moist, well-drained, nutrient rich soils, in a sheltered and sunny location. However, the characteristics of different plant species are often expressed in term of the tolerance to adverse environmental conditions, such as poor soil, shade, low pH and wind. Characteristics of the recommended species in Tables E1 to E7 are shown in Appendix F.

Appendix F

Suggested List of Plant Species for Slope Works

This Appendix contains matrices showing the characteristics of the plant species recommended in Appendix E, and the plant species categorised as follows:

- Herbs (including grasses and ferns)
- Climbers
- Shrubs
- Small trees (normally around 3 m in height (DEVB, 2010b))
- Medium trees (much taller than 3 m but with a small crown (DEVB, 2010b))
- Large trees (normally taller than 10 m with a large crown (DEVB, 2010b))

Data in the matrices for the selected species are based on the plant selection matrix developed primarily under the following studies:

(a) *Study on the Application of Various Vegetation Species for Landscaping of Man-made Slopes in Hong Kong* (HCL, 2011a), and

(b) *Study on Application of Various Vegetation Species on Man-made Slopes* (HCL, 2011b).

The botanical or scientific names of plants are in Latin and are the common usage worldwide. Scientific names are always written in italics with the genus name first (the first letter of which is always capitalised) and the species name second (all in lower case), e.g. *Acacia mangium*. The name in parentheses following the scientific name is the English common name. All plant names follow the Hong Kong Herbarium Hong Kong Plant Database (http://www.hkherbarium.net/Herbarium/frame.html), and are supplemented by the Flora of China database (http://www.efloras.org/index.aspx).

Illustrative photographs of selected species are provided at the back of this Appendix. The *Field Guide to Trees in Hong Kong's Countryside* (AFCD, 2008a) provides photographs and additional information, which are particularly useful for identification of species for Tree Surveys. In addition, the *Flora of Hong Kong* (AFCD, 2007; 2008b; 2009 & 2011) provides comprehensive botanical information of the plants of Hong Kong. Taxonomic changes to plant species in Hong Kong that were included in the *Flora of Hong Kong* (AFCD, 2007; 2008a; 2009 & 2011) are also updated in this Appendix.

Table F1 Plant Selection Matrix (Sheet 1 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Climber[1]																																	
Hedera helix (Ivy)	洋常春藤		*		√				√			√	√			√										Gm				√	√		√
Bougainvillea spectabilis (Beautiful Bougainvillea)	葉子花		*		√			√				√	√			√							R,P	12-5		Gm	√			√	√	√	
Duranta erecta (Golden Dewdrops)	假連翹		*		√			√				√	√			√							Y	3-5	D	Gl					√		√
Embelia ribes (White-flowered Embelia)	白花酸藤子	√			√							√	√			√			√		√		W	1-7	W	Gm				√		√	
Ficus pumila (Creeping Fig)	薜荔	√			√			√				√			√	√			√		√			4-12	D	Gd						√	
Parthenocissus dalzielii (Diverse-leaved Creeper)	異葉爬牆虎		*			√			√			√		√		√										Gl	√						
Smilax glabra (Glabrous Greenbrier)	土茯苓	√			√			√				√	√			√			√		√		W	7-11	D	Gl				√		√	

Table F1 Plant Selection Matrix (Sheet 2 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Herb																																	
Alocasia macrorrhiza (Giant Alocasia)	海芋		*		√				√			√	√			√					√		W	R	D	Gl							√
Axonopus compressus (Carpet Grass)	地毯草		*						√			√	√			√										Gm						√	
Blechnum orientale (Oriental Blechnum)	烏毛蕨	√			√				√			√	√			√										Gl				√			√
Cenchrus echinatus (Bur Grass)	蒺藜草		*						√	√			√			√								6-8	W	Gl						√	
Chloris gayana (Rhodes-grass)	非洲虎尾草		*						√			√	√			√																√	
Cynodon dactylon (Couch Grass)	狗牙根	√							√			√	√			√								5-10	W	Gl						√	
Dicranopteris pedata (Dichotomy Forked Fern)	芒萁	√			√				√			√	√			√										Gl	√			√		√	
Eragrostis curvula (Oulandgrass)	彎葉畫眉草	√							√			√	√			√										Gl						√	

Table F1 Plant Selection Matrix (Sheet 3 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Herb (Cont'd)																																	
Eremochloa ophiuroides (Smooth Lawn Grass)	假儉草	√							√			√	√			√								6-11	R	Gl						√	
Lolium perenne (Perennial Ryegrass)	黑麥草		*						√			√	√			√										Gl						√	
Paspalum notatum (Bahiagrass)	百喜草		*						√			√	√			√							W			Gl	√	√		√		√	
Zoysia japonica (Korean Lawngrass)	結縷草		*						√			√	√			√										Gl						√	
Zoysia matrella (Manila Grass)	溝葉結縷草	√							√			√	√			√								7-10	R	Gl						√	

Table F1 Plant Selection Matrix (Sheet 4 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value					Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Shrub																																		
Aglaia odorata (Mock Lime)	米仔蘭		*		√							√	√			√							Y	5-12	D	Gd						√	√
Ardisia crenata (Hilo Holly)	朱砂根	√			√			√				√	√			√							W	5-6	D	Gd							√
Bambusa tuldoides (Verdant Bamboo)	花眉竹	√					√	√				√	√			√										Gl	√				√		√
Calliandra haematocephala (Pink Powder Puff)	朱纓花		*					√				√	√			√			√				R	8-9	D	Gd						√	
Chrysalidocarpus lutescens (Bamboo Palm)	散尾葵		*		√			√				√			√	√										Gl						√	√
Cordyline fruticosa (Iron Plant, Tree of King)	朱蕉		*		√			√				√		√		√							W			Gl/ Red						√	√
Diplospora dubia (Common Tricalysia)	狗骨柴	√			√			√				√	√			√					√		Y	3-12	D	Gd	√			√		√	
Gardenia jasminoides (Cape Jasmine)	梔子	√			√			√				√	√			√					√		W	3-8	D	Gm	√			√		√	

Table F1 Plant Selection Matrix (Sheet 5 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Shrub (Cont'd)																																	
Hibiscus rosa-sinensis (Chinese Hibiscus)	朱槿 (大紅花)		*		√			√				√	√			√			√				R	R	D	Gd					√	√	
Ixora chinensis (Chinese Ixora)	龍船花	√			√			√				√	√			√			√				R	2-11		Gm	√			√	√	√	
Lantana montevidensis (Trailing Lantana)	小葉馬纓丹		*		√			√				√	√			√			√				Pi	R	R	Gl	√			√	√	√	
Ligustrum sinense (Chinese Privet)	山指甲	√			√			√				√		√		√				√	√		W	9-12	D	Gl				√	√		√
Litsea rotundifolia var. *oblongifolia* (Oblong-leaved Litsea)	豺皮樟	√			√			√				√	√			√					√		Y	8-9	D	Gm						√	
Melastoma malabathricum [2] (Common Melastoma)	野牡丹	√			√							√	√			√			√		√		Pi	5-7	D	Gl	√			√	√	√	
Melastoma sanguineum (Blood-red Melastoma)	毛蒽	√			√							√	√			√			√		√		Pi	8-10	D	Gm	√			√	√	√	
Pittosporum tobira (Pittosporum)	海桐		#		√			√				√			√	√							W	6-8	D	Gd	√	√		√	√	√	

Table F1 Plant Selection Matrix (Sheet 6 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Shrub (Cont'd)																																	
Psychotria asiatica (Wild Coffee)	九節	√			√			√				√	√			√					√		W	R	D	Gd							√
Rhaphiolepis indica (Hong Kong Hawthorn)	石斑木	√			√			√				√			√	√			√		√		W	2-4	D	Gd	√			√	√	√	
Rhapis excelsa (Lady Palm)	棕竹	√			√			√				√		√		√							W	6-9		Gm						√	√
Rhododendron mucronatum (White Azalea)	白杜鵑		*		√			√				√			√	√			√				W	2-3	W	Gl				√		√	√
Rhododendron pulchrum (Lovely Azalea)	錦繡杜鵑		*		√			√				√			√	√			√				Pi	2-4	W	Gl				√		√	√
Rhododendron pulchrum var. *phoeniceum* (Purple Azalea)	紫杜鵑花		*		√			√				√			√	√			√				P	2-3	W	Gl				√		√	√
Rhododendron simsii (Red Azalea)	紅杜鵑	√			√			√				√			√	√			√				R	2-3	W	Gl				√		√	√
Rhodomyrtus tomentosa (Rose Myrtle)	桃金孃	√			√			√				√	√			√			√		√		Pi	4-5	W	Gl	√	√	√	√	√	√	

Table F1 Plant Selection Matrix (Sheet 7 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value					Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Small Tree																																	
Bridelia tomentosa (Pop-gun Seed)	土密樹	√			√			√				√	√	√		√				√	√		W	3-12	D	Gl				√		√	√
Caryota mitis (Small Fishtail Palm)	短穗魚尾葵		*		√			√				√		√		√								4-5	R	Gd						√	√
Cratoxylum cochinchinense (Yellow Cow Wood)	黃牛木	√				√		√				√		√		√			√				R	4-5	W	Gl	√			√	√	√	√
Cyclobalanopsis championii (Champion's Oak)	嶺南青岡	√			√			√				√		√	√	√						√	Y	12-3	D	Gd	√			√		√	√
Cyclobalanopsis myrsinifolia (Small-leaved Oak)	小葉青岡	√			√			√				√		√	√	√						√	Y	6	D	Gm	√			√		√	√
Elaeocarpus chinensis (Chinese Elaeocarpus)	中華杜英	√			√			√				√		√		√					√		G	5-6	D	Gm				√		√	
Ficus hispida (Opposite-leaved Fig)	對葉榕	√			√			√				√		√		√			√					5-10	W	Gl							√

Table F1 Plant Selection Matrix (Sheet 8 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value					Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Small Tree (Cont'd)																																	
Ilex viridis (Small-leaved Holly)	綠冬青	√			√			√				√		√		√			√		√		W	5-6	D	Gm							√
Mallotus apelta (White-back Leaf Mallotus)	白背葉	√			√			√				√	√			√			√			√	W	6-9	D	Gl	√			√		√	
Melicope pteleifolia (Thin Evodia)	三椏苦	√				√						√	√			√			√	√		√	W	11-12	D	Gl				√	√	√	
Ormosia emarginata (Emarginate-leaved Ormosia)	凹葉紅豆	√			√			√				√			√		√						W	5-6	D	Gl							√
Phyllanthus emblica (Myrobalan)	餘甘子	√					√	√				√			√	√			√		√		Y	4-6	W	Gd	√		√	√		√	
Polyspora axillaris [2] (Hong Kong Gordonia)	大頭茶	√			√			√				√		√		√			√				W	10-1	D	Gd	√	√	√	√	√	√	
Pyrus calleryana (Callery Pear)	豆梨	√					√	√				√		√		√			√		√		W	2-4	D	Gl	√			√		√	

Table F1 Plant Selection Matrix (Sheet 9 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Small Tree (Cont'd)																																	
Reevesia thyrsoidea (Reevesia)	梭羅樹	√				√		√				√	√			√			√			√	W	3-4	D	Gl	√		√	√	√	√	
Rhus succedanea (Wax Tree)	木蠟樹	√					√	√				√				√						√	W	4-5	D	Gl						√	
Ternstroemia gymnanthera (Naked Anther Ternstroemia)	厚皮香	√			√			√				√		√		√			√			√	Y	5-7	W	Gm	√			√		√	
Washingtonia robusta (Petticoat Palm)	華盛頓葵		*		√			√				√			√		√									Gm	√	√		√	√	√	
Zanthoxylum avicennae (Prickly Ash)	簕欓	√			√			√				√	√			√			√	√		√	W	6-8	D	Gl	√			√	√	√	

Table F1 Plant Selection Matrix (Sheet 10 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Medium Tree																																	
Acacia auriculiformis (Ear-leaved Acacia)	耳果相思		*		√			√				√	√				√					√	Y	3-5	D	Gl	√	√		√	√	√	
Alangium chinense (Chinese Alangium)	八角楓	√					√	√				√		√		√			√		√		Y	5-10	R	Gl						√	√
Aporusa dioica (Aporusa)	銀柴	√			√			√				√		√		√				√	√		W	R	D	Gm				√		√	√
Bauhinia purpurea (Purple Camel's Foot)	紅花羊蹄甲		*		√			√				√	√			√							R	7-11	W	Gl	√	√			√	√	
Bauhinia variegata (Camel's Foot Tree)	宮粉羊蹄甲		*		√			√				√	√			√							R	7-11	W	Gl	√	√			√	√	
Cinnamomum burmannii (Batavia Cinnamon, Cinnamon Tree)	陰香	√			√			√				√		√			√						W	9-2	W	Gd	√				√	√	
Cyclobalanopsis neglecta (Bamboo-leaved Oak)	竹葉青岡	√			√			√				√	√					√				√	Y	6	D	Gl	√			√		√	√
Diospyros morrisiana (Morris's Persimmon)	羅浮柿	√			√			√				√		√		√					√		W	5-6	D	Gm				√		√	√

Table F1 Plant Selection Matrix (Sheet 11 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Medium Tree (Cont'd)																																	
Garcinia oblongifolia (Lingnan Garcinia)	嶺南山竹子	√			√			√				√		√		√			√		√		Y	4-5	D	Gd							√
Litsea glutinosa (Pond Spice)	潺槁樹	√			√			√				√		√			√		√		√		Y	5-6	W	Gm						√	√
Macaranga tanarius (Elephant's Ear)	血桐	√			√			√				√	√			√			√			√	Y	4-5	W	Gl	√	√			√	√	
Machilus breviflora (Short-flowered Machilus)	短序潤楠	√			√			√				√			√		√		√		√		Y	7-8	D	Gm	√			√		√	√
Mallotus paniculatus (Turn-in-the-wind)	白楸	√			√			√				√	√			√			√			√	W	7-10	D	Gl	√			√	√	√	√
Melia azedarach (China-berry)	楝		#				√					√	√			√			√	√	√		P	4-5	D	Gl	√			√	√	√	
Myrica rubra (Strawberry Tree)	楊梅	√			√			√				√		√		√			√		√		R	3-4	W	Gd					√	√	
Ormosia semicastrata (Soft-fruited Ormosia)	軟莢紅豆	√			√			√				√			√		√						W	4-5	D	Gm							√

Table F1 Plant Selection Matrix (Sheet 12 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Medium Tree (Cont'd)																																	
Phoenix hanceana (Spiny Date Palm)	刺葵	√			√			√				√			√	√							Y	4-5	W	Gd				√	√	√	
Sapium discolor (Mountain Tallow Tree)	山烏桕	√					√	√				√	√			√			√	√		√	Y	4-6	D	Gl						√	
Schefflera heptaphylla (Ivy Tree)	鵝掌柴	√			√			√				√	√			√			√		√		W	11-12	D	Gm	√	√		√	√	√	√
Syzygium levinei (Levine's Syzygium)	山蒲桃	√			√			√				√		√			√		√				W	7-9	W	Gm	√	√		√		√	
Tutcheria spectabilis (Common Tutcheria)	石筆木	√			√			√				√		√			√		√			√	W	6	D	Gm	√			√		√	√
Viburnum odoratissimum (Sweet Viburnum)	珊瑚樹	√			√			√				√	√				√				√		W	3-4	D	Gd	√	√			√	√	√

Table F1 Plant Selection Matrix (Sheet 13 of 13)

Scientific name (Common name)	Chinese name	Origin			Characteristic								Growth rate			Life span			Ecological value				Ornamental value				Tolerance - environmental factors						
		Native	* denotes Exotic, # denotes Naturalised Exotic	Provenance	Evergreen	Semi-deciduous	Deciduous	Woody	Herbaceous	Annual	Biennial	Perennial	Fast growing	Medium growing	Slow growing	Short life span (< 20 - 50 yr)	Medium life span (50 - 80 yr)	Long life span (80+ yr)	Flower nectar for insects	Larval foodplants for insects	Fruits for wildlife	Seeds for wildlife	Flower colour: R-red, W-white, Y-yellow, P-purple, Pi-pink	Flowering period: 1-Jan, 2-Feb…etc., R-year round	Fruiting period: D-dry season, W-wet season, R-year round	Foliage colour: Gl-light green, Gm-medium green, Gd-dark green, Red-red before falling	Wind tolerant	Salt spray tolerant	Fire tolerant	Drought tolerant	Pollution tolerant	Sunlight tolerant	Shade tolerant
Large Tree																																	
Cassia siamea (Kassod Tree)	鐵刀木		*		√			√				√	√			√							Y	10-11	D	Gm	√	√		√	√	√	
Castanopsis fissa (Castnaopsis)	黧蒴錐	√			√			√				√	√				√					√	Y	4-5	D	Gm	√			√		√	√
Choerospondias axillaris (Hog Plum)	南酸棗	√					√	√				√	√				√				√		R,P	4-8	D	Gm	√		√	√		√	
Lithocarpus harlandii (Harland's Tanbark)	港柯	√			√			√				√		√				√				√	Y	5-6	D	Gd							
Schima superba (Schima)	木荷	√			√			√				√	√				√		√				W	6-8	D	Gm	√		√	√	√	√	
Syzygium hancei (Hance's Syzygium)	韓氏蒲桃	√			√			√				√		√			√		√		√		W	7-9	D	Gm	√			√		√	√

[1] All climber species included in this matrix are able to climb upward as well as downward.

[2] According to the *Flora of Hong Kong*, *Melastoma candidum* and *Gordonia axillaris* are now synonym of *Melastoma malabathricum* and *Polyspora axillaris* respectively.

Climber and Herb **1 of 3**

Climber:

Bougainvillea spectabilis
(Beautiful Bougainvillea) 葉子花

Duranta erecta
(Golden Dewdrops) 假連翹

Embelia ribes
(White-flowered Embelia) 白花酸藤子

Ficus pumila (Creeping Fig) 薜荔

Climber and Herb **2 of 3**

Climber:

Parthenocissus dalzielii
(Diverse-leaved Creeper) 異葉爬牆虎

Smilax glabra
(Glabrous Greenbrier) 土茯苓

Herb:

Alocasia odora
(Giant Alocasia) 海芋

Climber and Herb **3 of 3**

Herb:

Axonopus compressus
(Carpet Grass) 地毯草

Blechnum orientale
(Oriental Blechnu) 烏毛蕨

Paspalum notatum (Bahiagrass) 百喜草

Dicranopteris pedata (Dichotomy Forked Fern) 芒萁

Shrub **1 of 4**

Ardisia crenata
(Hilo Holly) 朱砂根

Chrysalidocarpus lutescens
(Bamboo Palm) 散尾葵

Cordyline fruticosa
(Iron Plant) 朱蕉

Diplospora dubia
(Common Tricalysia) 狗骨柴

Shrub **2 of 4**

Gardenia jasminoides
(Cape Jasmine) 梔子

Ixora chinensis
(Chinese Ixora)
龍船花

Lantana montevidensis
(Trailing Lantana) 小葉馬纓丹

Shrub **3 of 4**

Ligustrum sinense
(Chinese Privet) 山指甲

Litsea rotundifolia var. *oblongifolia*
(Oblong-leaved Litsea) 豺皮樟

Melastoma malabathricum
(Common Melastoma) 野牡丹

Melastoma sanguineum
(Blood-red Melastoma) 毛蒽

Pittosporum tobira
(Pittosporum) 海桐

Psychotria asiatica
(Wild Coffee) 九節

Shrub **4 of 4**

Rhaphiolepis indica
(Hong Kong Hawthorn) 石斑木

Rhapis excelsa
(Lady Palm Thorn) 棕竹

Rhododendron mucronatum
(White Azalea) 白杜鵑

Rhododendron pulchrum var. *phoeniceum*
(Purple Azalea) 紫杜鵑花

Rhodomyrtus tomentosa
(Rose Myrtle) 桃金娘

Rhododendron simsii
(Red Azalea) 紅杜鵑

Small Tree **1 of 4**

Bridelia tomentosa
(Pop-gun Seed) 土蜜樹

Caryota mitis
(Small Fishtail Palm) 短穗魚尾葵

Cratoxylum cochinchinense
(Yellow Cow Wood) 黃牛木

Cyclobalanopsis championii
(Champion's Oak) 嶺南青岡

Cyclobalanopsis myrsinifolia
(Small-leaved Oak) 小葉青岡

Elaeocarpus chinensis
(Chinese Elaeocarpus) 中華杜英

Small Tree **2 of 4**

Ficus hispida
(Opposite-leaved Fig) 對葉榕

Ilex viridis
(Small-leaved Holly) 綠冬青

Mallotus apelta
(White-back Leaf Mallotus) 白背葉

Melicope pteleifolia
(Thin Evodia) 三椏苦

Ormosia emarginata
(Emarginate-leaved Ormosia) 凹葉紅豆

Small Tree **3 of 4**

Phyllanthus emblica
(Myrobalan) 餘甘子

Polyspora axillaris
(Hong Kong Gordonia) 大頭茶

Pyrus calleryana
(Callery Pear) 豆梨

Small Tree **4 of 4**

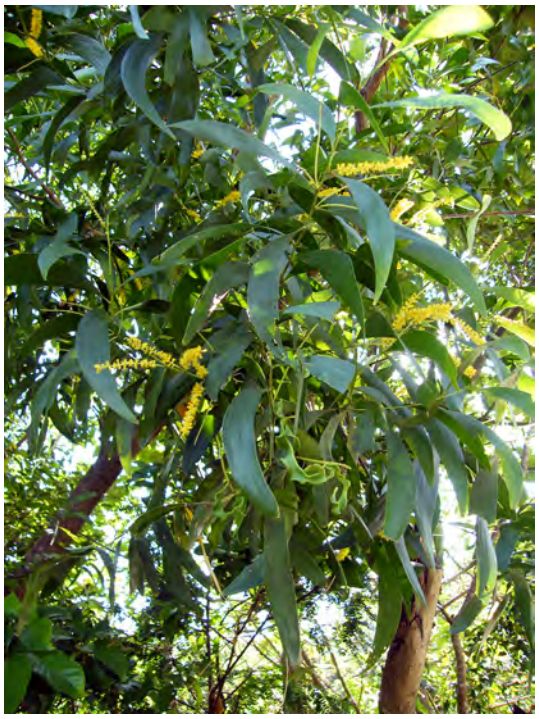
Reevesia thyrsoidea
(Reevesia) 梭羅樹

Rhus succedanea (Wax Tree) 木蠟樹

Ternstroemia gymnanthera
(Naked Anther Ternstroemia) 厚皮香

Zanthoxylum avicennae
(Prickly Ash) 簕欓

Medium Tree **1 of 4**



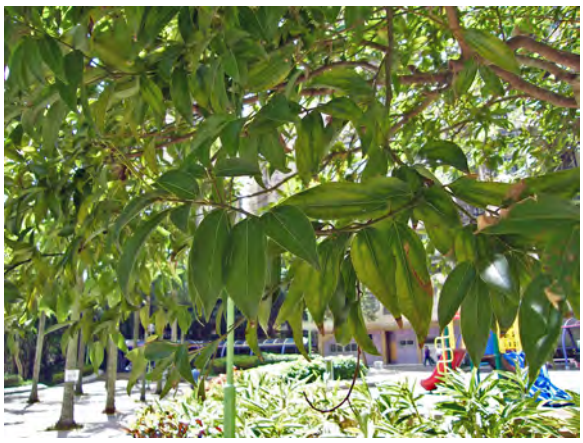
Acacia auriculiformis
(Ear-leaved Acacia) 耳果相思

Aporusa dioica (Aporusa) 銀柴

Alangium chinense (Chinese Alangium) 八角楓

Medium Tree **2 of 4**

Bauhinia variegata
(Camel's Foot Tree) 宮粉羊蹄甲



Cinnamomum burmannii
(Batavia Cinnamon, Cinnamon Tree) 陰香

Cyclobalanopsis neglecta
(Bamboo-leaved Oak) 竹葉青岡

Diospyros morrisiana
(Morris's Persimmon) 羅浮柿

Garcinia oblongifolia
(Lingnan Garcinia) 嶺南山竹子

Litsea glutinosa
(Pond Spice) 潺槁樹

Medium Tree **3 of 4**

Macaranga tanarius
(Elephant's Ear) 血桐

Machilus breviflora
(Short-flowered Machilus) 短序潤楠

Melia azedarach (China-berry) 楝

Mallotus paniculatus
(Turn-in-the-wind) 白楸

Ormosia semicastrata
(Soft-fruited Ormosia) 軟莢紅豆

Medium Tree **4 of 4**

Myrica rubra (Strawberry Tree) 楊梅

Phoenix hanceana
(Spiny Date Palm) 刺葵

Sapium discolor
(Mountain Tallow Tree) 山烏桕

Schefflera heptaphylla
(Ivy Tree) 鵝掌柴

Syzygium levinei
(Levine's Syzygium) 山蒲桃

Viburnum odoratissimum
(Sweet Viburnum) 珊瑚樹

Large Tree **1 of 2**

Castanopsis fissa (Castanopsis) 黧蒴錐

Choerospondias axillaris (Hog Plum) 南酸棗

Large Tree **2 of 2**

Lithocarpus harlandii (Harland's Tanbark) 港柯

Schima superba (Schima) 木荷

Appendix G

Notes on the Implementation of Landscape Works

The requirements for landscape treatments should be stated on the landscape works drawings and in the specifications. Those responsible for supervising the implementation of landscape treatments should ensure that the requirements of the drawings and appropriate sections of the GS and PS are fully understood at the outset of the contract and any discrepancies or omissions raised with the designer before commencement of works. During the course of the works adjustment of engineering elements (e.g. soil nail heads, grillage systems or crest channel drains) may be necessary to suit actual site conditions particularly to avoid tree roots and to allow for actual ground conditions. Designers may instruct such changes following routine design validation inspections or alternatively referral to designers by supervisory staff may be necessary.

Tables G1, G2 and G3 suggest some of the more typical items aspects that need to be addressed in the construction of landscape works.

Contractors should be requested to submit detailed method statements, for approval before commencement, for any construction operations within tree protection zones, to demonstrate both the methods and control procedures to ensure full protection of trees.

Table G1 Supervision of Tree Protection Measures

Works	Consideration
Site clearance works	• Confirmatory tree survey undertaken by the contractor • Identification and clear marking of existing trees/vegetation to be retained, including tree protection zones • Installation of protection measures and any necessary temporary supports • Tree trimming operations (only with prior written approval) • Tree felling (only with written prior approval), checking identification of trees, reinstatement of disturbed areas • Avoiding damage to roots of ferns and small shrubs which are to be trimmed back as part of site clearance so that they may re-grow
Tree transplanting (unlikely to be required for trees on slopes)	• Checking of method statement against specification requirements • Tree preparation, root and crown pruning • Preparation of receptor locations • Access arrangements, rootball preparation before lifting, and lifting mechanism • Tree care during transportation • Replanting operations • Installation of supporting structures • Watering and aftercare operations
Works within tree protection zones (tree support structures, soil nails/grillage structures, trenching for utilities, etc.)	• Identification of major tree roots • Alignment and positioning of engineering elements • Construction of any temporary working platforms or access route • Excavation around/under roots • Temporary tree protection measures against compaction, impact damage, exhaust fumes, vibration, etc. • Tree trimming
Tree rings	• Location, size, shape • Edge formation

Table G2 Supervision of Landscape Softworks

Works	Consideration
Erosion protection mats	• Preparation of surface • Laying, fixing, jointing/overlapping • Cutting around edges and to allow for planting
Top-soiling and soil-mix	• Quality, consistency and quantity of soil-mix materials and workmanship • Addition of soil conditioner • Depths, compaction rates and settlement, surface levels • Relation to soil erosion matting or geotechnical features
Mulching	• Quality, consistency and quantity of materials and workmanship • Temporary stockpiling on site • Depths, compaction rates and settlement, surface levels
Fertilizing	• Quality of materials • Rates and method of application
Grassing	• Quality and mix of seeds • Evenness and extent of coverage, germination rates • Fabric membrane/geotextile cover, setting out, securing and erosion control
Planting	• Type, quality and size of nursery stock • Maintenance of nursery stock on site • Setting out, pit excavation, backfilling, finished levels • Planting, plant care, level in relation to soil, setting vertical • Irrigation water supply in relation to timing of planting works
Staking and guying	• Quality of materials and workmanship • Setting out in relation to paving and other site features
Establishment works	• Attendance of contractor • Health of plants when delivered • Validating species • Replacement of defective plant material • Watering, weeding, firming up, stakes and ties, fertilizing, etc.

Table G3 Supervision of Engineering Elements and Slope Furniture and Associated Landscape Hardworks

Works	Consideration
Concrete works	• Quality and consistency of concrete surface finish, pattern/texture and colour • Evenness of edges • Alignment of joints • Adjustment to suit site conditions (i.e. to avoid trees and tree roots) • Surface crossfalls • Prevention of grout spill during soil nailing
Sprayed concrete works	• Quality and consistency of concrete surface finish and colour • Protection of adjacent vegetation and surfaces • Prevention of overspray of sprayed concrete
Slope furniture (handrails, metal stairways, gates, fences, etc.)	• Setting out and alignment • Quality and consistency of joints and fixing • Quality and consistency of edges and surface finishes (especially with any site fabrication) • Paint finishes and galvanising
Drainage works	• Location of channels and catchpits – adjust to suit on site topography and to avoid trees and tree roots • Positioning of raking drains – adjust to suit actual site conditions
Applied finishes (masonry, stone blockwork, tiling, precast panels, cladding systems, artificial rock, etc.)	• Trial panels • Horizontal/vertical alignment, orientation • Consistency of patterning • Colour mix • Evenness of surface • Filling of joints
Metalwork	• Colour • Evenness of application • Laying of wire mesh and providing openings for planting

Appendix H

Landscape Maintenance Manuals and Inspections

Geoguide 5 (GEO, 2003a) provides guidance on the content of Maintenance Manual (MM), Routine Maintenance Inspections (RMI) and Engineer Inspections (EI) of slopes, including their frequency and timing.

Landscape items should be included in MM and as part of RMI and EI processes. Tables H1, H2 and H3 provide checklists of items that may need to be addressed in MM, RMI and EI.

Table H1 Landscape Items which may be Included in Maintenance Manual in addition to Items Listed in Geoguide 5

Maintenance advice
Vegetation generally: • Clear vegetation from drainage system (e.g. channels and weepholes) • Clear encroaching vegetation from access routes, which is inhibiting access • Clear disruptive vegetation growth from: - exposed rock surfaces - concrete surface and structures - masonry surfaces and structures - metal surfaces (e.g. handrails, fences, gates)
Landscape softworks
Natural vegetation cover: • Regrade eroded areas with compacted soil followed by planting. Replant vegetation in areas where there is no canopy or leaf litter cover • Remove unstable trees Planned vegetation: • Regrade eroded areas and backfill with compacted soil followed by re-grassing to the entire regraded areas • Re-grass/Re-vegetate the bare slope surface • Remove undesirable vegetation • Remove unstable trees, prune trees and implement re-planting Proprietary systems: • Repair eroded areas • Re-vegetate as necessary
Landscape hardworks
• Remove disruptive vegetation growth • Repair, repaint, replace landscape hardworks treatments to: - concrete surfaces and structures - masonry surfaces and structures - metalwork surfaces

Note: Refer also to Section 3.6 of this Publication for other particular items which may need to be addressed in the MM.

Table H2 Routine Maintenance Inspection Checklist for Landscape Softworks

RECORD OF ROUTINE MAINTENANCE INSPECTION FOR LANDSCAPE SOFTWORKS				
SLOPE REFERENCE NO.				
Location of Slope/Retaining Wall (address)				
Maintenance Action	**Location Reference**	**Action Required**		**Works Completion Date**
		No	**Yes**	
Trimming of groundcover vegetation				
Re-vegetation of bare soil slope surface*				
Removal of unplanned vegetation on hard slope surface*				
Removal of invasive species (e.g. *Leucaena leucocephala* (銀合歡), *Pueraria* (野葛類), *Cassytha* (無根藤), *Mikania micrantha* (薇甘菊))				
Tree pruning*				
Removal of any dead trees*				
Replacement/Enlargement of tree ring				
Provision of tree ring				
Replacement of proprietary product				
Re-planting of vegetation				
Repair or re-provision of wire mesh				
Enlargement of wire mesh opening				
Others (specify works and give details)				

** Input from a landscape specialist or an arborist may be necessary.*

Table H3 Engineer Inspection Checklist for Landscape Softworks (1 of 2)

RECORD OF ENGINEER INSPECTION FOR LANDSCAPE SOFTWORKS		
SLOPE REFERENCE NO.		
CONDITION OF LANDSCAPE SOFTWORKS		
Items to be Checked	**Condition**	**Works Needed**
Planned groundcover vegetation (Yes/No)	Good/Bare/Overgrown	
Proprietary products (Yes/No)	Good/Bare/Overgrown	
Unplanned vegetation on hard slope surface * (Yes/No)	None/Fair/Overgrown	
Shrubs/Trees (General condition) (Yes/No)	Healthy/Declining/Dead	
Tree ring (Yes/No)	Adequate/Undersize	
Unplanned vegetation within planted areas * (Yes/No)	No apparent problem/Invasive/ Overgrown	
Planter holes (Yes/No)	Good/Fair/Poor	
Others (Specify)		
COMMENTS (continue on separate sheets if needed)		

* *Input from a landscape specialist or an arborist may be necessary.*

Table H3 Engineer Inspection Checklist for Landscape Softworks (2 of 2)

RECORD OF ENGINEER INSPECTION FOR LANDSCAPE SOFTWORKS			
SLOPE REFERENCE NO.			
CONDITION OF LANDSCAPE SOFTWORKS			
Obvious Tree Problems Observed (Notes 1 & 2) **(tick more than one box and circle item# where appropriate)**			
☐	severe leaning	☐	broken branch(es) hanging from tree
☐	large wound#/cracks or splits#/open cavity# on trunk(s) or branch(es)	☐	loosened bark
☐	termite#/fungal fruiting bodies#	☐	root damage
☐	dead branch(es)#/abnormal defoliation#	☐	excessive pruning
☐	Other supplementary information (please specify)		
Is follow-up inspection by a suitably qualified and experienced arborist (Note 3) considered necessary?			Yes/No#
Notes: (1) Carry out visual inspection as far as safe access is available. (2) See *Pictorial Guide for Tree Maintenance to Reduce Tree Risks* promulgated by the Greening, Landscape and Tree Management Section of Development Bureau (DEVB, 2011c) for illustration of tree problems. (3) Refer to http://www.trees.gov.hk/en/ for advice on qualifications and experience requirements by the Greening, Landscape and Tree Management Section of Development Bureau.			
COMMENTS (continue on separate sheets if needed)			

Appendix I

List of Government Policies and Guidelines Relating to Landscape Works

The following are the policy documents and guidelines relating to landscape works on slopes that are current at the time of printing this Publication. As these documents are periodically revised and superseded, practitioners should refer to the relevant government organisations for the latest information.

GENERAL DOCUMENTS

- *Tree Planting and Maintenance in Hong Kong*
  Standing Inter-departmental Landscape Technical Group, Hong Kong (SILTech, 1991)

- *General Specification for Civil Engineering Works (Volumes 1 and 2)*
  The Government of the Hong Kong Special Administrative Region (HKSARG, 2006)

POLICY BUREAU DOCUMENTS

Development Bureau (DEVB)

- *General Guidelines on Tree Pruning* (DEVB, 2007)

- *Design for Tree Protection Zone* (DEVB, 2010a)

- *Guiding Principles on Use of Native Species in Public Works Projects* (DEVB, 2010b)

- *Tree Care during Construction* (DEVB, 2010c)

- *Do's and Don'ts in Pruning* (DEVB, 2010d)

- *Keep Your Trees Safe* (DEVB, 2010e)

- *Guidelines for Tree Risk Management and Assessment Arrangement on an Area Basis and on a Tree Basis* (DEVB, 2011a)

- *Pictorial Guide for Tree Maintenance to Reduce Tree Risks* (DEVB, 2011b)

- *Maintenance of Man-made Slopes and Emergency Works to Deal with Landslides (Development Bureau Technical Circular (Works) No. 6/2011)* (DEVB, 2011c)

Environment, Transport and Works Bureau
(now part of Development Bureau)

- *Additional Measures to Improve Site Cleanliness and Control Mosquito Breeding on Construction Sites (Environment, Transport and Works Bureau Technical Circular (Works) No. 22/2003)* (ETWB, 2003a)

- *Community Involvement in Greening Works (Environment, Transport and Works Bureau Technical Circular (Works) No. 34/2003)* (ETWB, 2003b)

- *Role of Departmental Safety and Environmental Advisor on Health, Safety and Environmental Protection on Construction Sites (Environment, Transport and Works Bureau Technical Circular (Works) No. 14/2003)* (ETWB, 2003c)

- *Cyber Manual for Greening (Environment, Transport and Works Bureau Technical Circular (Works) No. 11/2004)* (ETWB, 2004b)

- *Maintenance of Vegetation and Hard Landscape Features (Environment, Transport and Works Bureau Technical Circular (Works) No. 2/2004)* (ETWB, 2004c)

- *Registration of Old and Valuable Trees, and Guidelines for their Preservation (Environment, Transport and Works Bureau Technical Circular (Works) No. 29/2004)* (ETWB, 2004d)

- *Environmental Management on Construction Sites (Environment, Transport and Works Bureau Technical Circular (Works) No. 19/2005)* (ETWB, 2005)

- *Tree Preservation (Environment, Transport and Works Bureau Technical Circular (Works) No. 3/2006)* (ETWB, 2006)

Works Bureau
(now part of Development Bureau)

- *Allocation of Space for Urban Street Trees (Works Bureau Technical Circular No. 25/92)* (Works Bureau, 1992)

- *Control of Visual Impact of Slopes (Works Bureau Technical Circular No. 25/93)* (Works Bureau, 1993)

- *Geotechnical Manual for Slopes - Guidance on Interpretation and Updating (Works Bureau Technical Circular No. 13/99)* (Works Bureau, 1999)

- *Improvement to the Appearance of Slopes (Works Bureau Technical Circular No. 17/2000)* (Works Bureau, 2000)

- *Tree Planting in Public Works (Works Bureau Technical Circular No. 7/2002)* (Works Bureau, 2002)

DEPARTMENTAL DOCUMENTS

Buildings Department

- *Improvement of Visual Appearance and Landscape Treatment for Man-made Slopes and Retaining Walls (Practice Note for Authorized Persons and Registered Structural Engineers and Registered Geotechnical Engineers, ADV-23 (Previously PNAP 270)* (BD, 2009)

Civil Engineering and Development Department: Geotechnical Engineering Office

- *Highway Slope Manual* (GEO, 2000a)
- *Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (GEO Publication No. 1/2000)* (GEO, 2000b)
- *Guide to Slope Maintenance (Geoguide 5)* (GEO, 2003a)
- *Layman's Guide to Slope Maintenance* (GEO, 2003b)
- *Updating of GEO Publication No. 1/2000 - Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (GEO Technical Guidance Note No. 20)* (GEO, 2007)
- *Prescriptive Measures for Man-made Slopes and Retaining Walls (GEO Publication No. 1/2009)* (GEO, 2009)

Environmental Protection Department

- *Technical Memorandum on Environmental Impact Assessment Process (Environmental Impact Assessment Ordinance Cap. 499, S.16, 1997)* (EPD, 1997)

Highways Department

- *Independent Vetting of Tree Works under the Maintenance of Highways Department (Highways Department Technical Circular No. 3/2008)* (HyD, 2008)
- *Control in the Use of Shotcrete (Sprayed Concrete) in Slope Works (Highways Department Technical Circular No. 2/2010)* (HyD, 2010a)
- *Requirements for Handover of Vegetation to Highways Department* (HyD, 2010b)

Lands Department

- *Compliance of Landscape Clause under Lease (Land Administration Office Practice Note No. 6/2003)* (LandsD, 2003)

- *Tree Preservation and Tree Removal Application for Building Development in Private Projects (Land Administration Office Practice Note No. 7/2007)* (LandsD, 2007)

Planning Department

- *Hong Kong Planning Standards and Guidelines* (PlanD, 2011)

Water Supplies Department

- *Guidance Notes for Landscape Works on WSD Slopes* (Urbis Ltd., 2003)

Glossary of Terms

Glossary of Terms

Aesthetic design. Design undertaken to improve appearance.

Bioengineering. 'The use of living vegetation, either alone or in conjunction with non-living plant material and civil engineering structures, to stabilise slopes and/or reduce erosion' or 'the use of any form of vegetation, whether a single plant or collection of plants, as an engineering material, i.e. one that has quantifiable characteristics and behavior'.

Broadcasting. The dispersal of seed by mechanical or manual means.

Climbing plant/climber. A plant whose natural habit is to climb upwards, relying for support on another tree, shrub, or on a slope or man-made structure. Some climbers could also hang down from the crest of the slope surface.

Coping feature. Separate top to a wall or parapet.

Creeping plant/creeper. Creepers usually spread by vegetative propagation on flat surfaces, forming a carpet-like appearance.

Ecological habitat. The environmental conditions that dictate the variety and type of living organisms which live in a given locality.

Ecological value. The relative value assigned to habitats or living organisms in any given location.

Establishment works. Active horticultural maintenance works undertaken to ensure healthy growth and development of plant material in the period immediately following planting.

Establishment Period. The contractually defined period of time immediately following the completion of planting during which establishment operations are carried out.

Exotic. Non-native plant material, i.e. originating from another part of the world.

Groundcover plant. Any low, dense-growing plant including ferns or herbaceous plants whose natural habit is to grow low and close to the ground and which is capable of covering the ground surface.

Hydro-mulching. Planting technique consisting of the application of a mulch of fibrous organic material in an aqueous suspension by low pressure spray onto a slope surface to create a layer of planting medium. The mulch is often mixed with grass/shrubs seeds.

Hydroseeding. The application of grass or grass/tree seed in combination with mulch, fertilizer and soil binding agent in an aqueous suspension by high pressure spray onto a soil surface to establish surface vegetation.

Hydro-sprigging. The application of individual grass plants in an aqueous suspension by high pressure spraying.

Indigenous plant species. Plant species living or occurring naturally in an area (in biogeographical context); also commonly referred to as native species.

Invasive species. Plant species that may adversely affect the habitats they invade, or that have since become a nuisance through rapid growth, often to the detriment of existing plant species.

Landscape architect. A professionally trained, qualified and registered practitioner of landscape architecture.

Landscape hardworks. The use of inert surface finishes or cladding to treat the surfaces of man-made structures and other engineering elements to make them visually more attractive. Such finishes may include masonry, sprayed concrete, concrete facing panels and the like.

Landscape softworks. All works of a horticultural nature, which include the placing, cultivation and preparation of topsoil and subsoil layers, and the supply and planting of trees, shrubs and other plant material, together with any works associated with these.

Landscape treatment. Enhancement of the appearance of a slope using landscape softworks or hardworks, or a combination of both.

Landscape value. An objective evaluation of the relative worth of a landscape or landscape element.

Micro-climate. The small-scale climatic characteristics pertaining to a given site or locality.

Mitigation measures. Engineering works carried out to mitigate risk from natural terrain failures, which may comprise natural terrain stabilisation works and/or natural terrain defense works. Landscaping should be carried out in association with such engineering works.

Natural terrain. Natural sloping ground generally unaltered by man, although within a natural hillside there may be portions of man-made slopes and areas of disturbed terrain. The characteristics of natural terrain varies both in terms of steepness, soil type and extent of weathering, the presence of boulders and rock outcrops, natural drainage lines, previous landslide scars, and the presence and types of vegetation.

Ornamental. Plants with distinct decorative characteristics.

Pioneer species. A plant species that establishes and grows to maturity quickly, and that is used within a planting design to form a rapid vegetative cover which can modify the micro-climatic conditions to favour slower growing native plants. Removal of pioneer species may be required, after a few years of growth, to promote more rapid natural regeneration.

Pit planting. The planting of plants in excavated pits which are then backfilled with topsoil.

Plant species. Particular variety of plant.

Plant type. Grass, shrubs, trees, climbers, groundcover, etc.

Planting season. The most favourable time of year for planting.

Seedling. A tree, typically one to two years old, with a single stem, well-developed root system and a height of between 150 mm and 900 mm.

Self-supporting plant. Plant capable of surviving without the need for physical support.

Shrub. A woody perennial plant with a bushy habit, often with several stems arising near the base.

Slope engineering elements. Engineering components used in the formation, stabilisation and operation of man-made slopes and natural terrain; including concrete soil nail heads and grillages, concrete drainage channels, associated catchpits, concrete access stairways, concrete berms, sprayed concrete, buttresses for rock stabilisation and the like.

Slope furniture. Elements that do not form part of the slope, but are required to facilitate safety or maintenance, e.g. handrails, metal stairways, access gates, fences, etc.

Slope works. Any engineering works to form, stabilise, upgrade, repair, restore or maintain either a man-made slope or retaining wall, or works to repair landslide scar or mitigate the potential effects of landslides on natural terrain.

Slope rehabilitation works. Combinations of slope engineering works and landscape works to improve slope safety and enhance the visual appearance particularly to slope areas described as degraded landscape. Examples include former quarry faces and slopes on old landfills.

Soil pocket. A small self-contained volume of soil capable of supporting plant growth.

Standard tree. A tree with a sturdy straight stem at least 1800 mm high from soil level to the lowest branch, a stem diameter of 45 mm to 75 mm measured at a height of 600 mm above soil level, a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry, according to species and a total height above soil level of between 2.75 m and 3.5 m.

Sustainable. Capable of being sustained, or maintained at a steady level without exhausting natural resources or causing ecological damage.

Trailing plant. Plants whose natural growth habit is to extend and droop over surfaces.

Tree. A woody perennial plant with a trunk diameter of 95 mm or more at a height of 1.3 m above the ground level.

Tree thinning. A tree removal practice that reduces tree density and competition amongst trees in a stand. Thinning concentrates growth on fewer, high-quality trees and generally enhances tree vigour. Heavy thinning can benefit wildlife through the increased growth of ground vegetation.

Tree transplanting. The uplifting of a tree (or other plant) from its original location, then transporting and replanting it in a new location.

Turfing. The laying of cut grass sods to create a grass sward.

Understorey. Plant species that naturally grow in the lower levels of woodland.

Undesirable vegetation. Plants which have dispersed or invaded into a landscaped area and which are regarded as invasive or not in compliance with the landscape objectives, together with plants which have overgrown to obstruct drainage channel or maintenance access.

Visual amenity/quality. An evaluation of the relative visual worth of a landscape or visual landscape element.

Water retaining agro-polymers. Proprietary polymer crystals which absorb moisture and when mixed with soil can improve its water holding capacity and the amount of water available for plant growth.

Whip. A tree specimen, typically two to three years old, with a single central stem well furnished with side branches, a well-developed and vigorous root system and a height of between 900 mm and 2000 mm.

Woodland. An area covered with trees, typically with an understorey of shrubs and herbaceous plants.

GEO PUBLICATIONS AND ORDERING INFORMATION
土力工程處刊物及訂購資料

A selected list of major GEO publications is given in the next page. An up-to-date full list of GEO publications can be found at the CEDD Website http://www.cedd.gov.hk on the Internet under "Publications". Abstracts for the documents can also be found at the same website. Technical Guidance Notes are published on the CEDD Website from time to time to provide updates to GEO publications prior to their next revision.

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MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS
土力工程處之主要刊物

GEOTECHNICAL MANUALS

Geotechnical Manual for Slopes, 2nd Edition (1984), 302 p. (English Version), (Reprinted, 2011).

斜坡岩土工程手冊(1998)，308頁(1984年英文版的中文譯本)。

Highway Slope Manual (2000), 114 p.

GEOGUIDES

Geoguide 1	Guide to Retaining Wall Design, 2nd Edition (1993), 258 p. (Reprinted, 2007).
Geoguide 2	Guide to Site Investigation (1987), 359 p. (Reprinted, 2000).
Geoguide 3	Guide to Rock and Soil Descriptions (1988), 186 p. (Reprinted, 2000).
Geoguide 4	Guide to Cavern Engineering (1992), 148 p. (Reprinted, 1998).
Geoguide 5	Guide to Slope Maintenance, 3rd Edition (2003), 132 p. (English Version).
岩土指南第五冊	斜坡維修指南，第三版(2003)，120頁(中文版)。
Geoguide 6	Guide to Reinforced Fill Structure and Slope Design (2002), 236 p.
Geoguide 7	Guide to Soil Nail Design and Construction (2008), 97 p.

GEOSPECS

Geospec 1	Model Specification for Prestressed Ground Anchors, 2nd Edition (1989), 164 p. (Reprinted, 1997).
Geospec 3	Model Specification for Soil Testing (2001), 340 p.

GEO PUBLICATIONS

GCO Publication No. 1/90	Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).
GEO Publication No. 1/93	Review of Granular and Geotextile Filters (1993), 141 p.
GEO Publication No. 1/2006	Foundation Design and Construction (2006), 376 p.
GEO Publication No. 1/2007	Engineering Geological Practice in Hong Kong (2007), 278 p.
GEO Publication No. 1/2009	Prescriptive Measures for Man-Made Slopes and Retaining Walls (2009), 76 p.
GEO Publication No. 1/2011	Technical Guidelines on Landscape Treatment for Slopes (2011), 217 p.

GEOLOGICAL PUBLICATIONS

The Quaternary Geology of Hong Kong, by J.A. Fyfe, R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk (2000), 210 p. plus 6 maps.

The Pre-Quaternary Geology of Hong Kong, by R.J. Sewell, S.D.G. Campbell, C.J.N. Fletcher, K.W. Lai & P.A. Kirk (2000), 181 p. plus 4 maps.

TECHNICAL GUIDANCE NOTES

TGN 1	Technical Guidance Documents