WORKSHOP ON CONCEPTS AND PRACTICES ON SLOPE BIOENGINEERING

Saturday, 19 November 2005
Lecture Theatre 1, Esther Lee Building
CUHK

Jointly organised by

Centre for Environmental Policy and Resource Management
Department of Geography and Resource Management

Industrial Ecology and Slope Ecotechnology Research Unit
Department of Biology

The Chinese University of Hong Kong

Preface

Slope stability and landslide problems are perennial to Hong Kong due to its topographic terrain and rainfall characteristics. During the past decades, geotechnical engineers have made great progress in tackling the problems and successfully avoided potential landslide hazards. Landscaping of cut slopes has recently attracted much attention. In addition to aesthetic values, it also can contribute to soil retention and slope stability. This is an area where engineers, soil and biological scientists, and landscape architects can work together and share their experiences and successes (as well as not so successful stories).

On behalf of the Centre for Environmental Policy and Resource Management, I welcome you all to CUHK and wish you a successful workshop. My admiration goes to the visions of the colleagues and professionals who initiate, organise and participate in the Workshop. I look forward to seeing the fruits of your workshop in consolidating the concepts and practices on slope bioengineering in Hong Kong, as well as developing the beautiful, sound and safe slopes in Hong Kong.

Professor Lam Kin Che
Director of Centre for Environmental Policy and Resource Management
Department of Geography and Resource Management
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Centre for Environmental Policy and Resource Management

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The institutional objective of the Centre is to facilitate and coordinate collaborative research in environmental science across departmental boundaries and foster a multi-disciplinary approach to the evaluation and analysis of environmental and resource issues.

The Centre aspires to resolve environmental problems for the benefit of the present and future generations through critical policy analysis, scientific advancement and application of frontier research findings. The Centre endeavours to integrate scientific research with policy-making, and to provide a forum for informed decision-making through scientific inquiry, open dialogue and public participation.

Industrial Ecology and Slope Ecotechnology Research Unit

(Contact: 2609 6378)

The Industrial Ecology and Slope Ecotechnology Research Unit, established in 2003 under the Department of Biology, aims to involve actively in the research and development in industrial ecology and slope landscaping, and to promote information exchange and collaboration with government departments and related industries in an expanding field of interdisciplinary interest. Major research areas include restoration of disturbed lands, bioremediation of contaminated areas, wastewater biotechnology, and slope greening.

Ongoing research projects include the ecological assessment of restored landfills, application of bioremediation techniques to clean up contaminated soils, the biotechnological treatment of industrial wastewaters, and the evaluation of the sustainability of landscaped cutslopes from a geoecological approach.

Workshop Programme

Morning Session – Paper Presentations and Open Discussion	
0830 – 0855	Registration and Exhibition
0855 – 0900	Welcome and Introduction
Paper Presentation - Session 1	
0900 – 0915	Introduction of Bioengineering into the Tropics *Ir David H Barker*
0915 – 0930	Ecological Greening *Mr Ken K Y So*
0930 – 0945	The Use of Soil Bioengineering Measures to Repair Selected Natural Terrain Landslides in Hong Kong *Mr Patrick Chao*
0945 – 1000	Slope Surface Protection with Natural Succession *Mr Albert Ho*
1000 – 1015	Biodiversity Recovery in Exotic Tree Plantations on Man-made Slopes in Hong Kong *Ms Ida M Y Yu*
1015 – 1030	A Review of the Field Performance of Native Tree and Shrub Species Planted on Man-made Slopes in Hong Kong *Dr Billy C H Hau*
1030 – 1045	Coffee Break
Paper Presentation - Session 2	
1045 – 1100	Fundamental Problems of Growth Substrates on Bioengineered Slopes in Hong Kong *Prof K C Chau*
1100 – 1115	The Paradoxical Role of Water in Slope Bioengineering *Ir Francis C H Wong*
1115 – 1130	Nutrient Analysis of Organic Fiber Soil For Slope Greening in Hong Kong *Mr Xiao-Yun Mao*
1130 -1145	Revegetation of Man-made Slopes from a Maintenance Perspective *Mr Eric W K Chan*
1145 – 1200	Green Revolution: Is there any Panacea for Slope Landscaping? *Prof L M Chu*
1200 – 1245	Open Discussion and Concluding Remarks
1245 – 1430	Lunch Buffet and Exhibition
Afternoon Session – Field Visits	
1430 – 1700	- R & D on Slope Bioengineering - Greening Techniques and Trial Panels - Case Studies
**Field visits will be organised within CUHK campus. Participants will be divided into 3 groups and visit each site in rotation.*	

Paper Abstracts (1)

The Introduction of Bioengineering into the Tropics

David H Barker

Prima Subur Sdn Bhd, Kuala Lumpur

The paper deals with the introduction of bioengineering into the tropics for the purposes of erosion control and slope stabilization. The paper details strategies for adapting classical bioengineering approaches and techniques for these purposes in different environmental (i.e. climate, vegetation types and soils), social and economic conditions. Terms adopted in slope bioengineering vary around the world – some reasons for this are explored.

The paper also discusses the challenges to and opportunities for long-term stability of formed slopes represented by the unique combination of either high year-round or intense seasonal rainfall, deeply weathered soils and pre-existing tropical or sub-tropical vegetation cover. In essence bioengineering approaches and techniques require to be low-cost and durable; they need to involve sustainable and appropriate materials and practices. The need to utilize local plant and knowledge resources is also emphasized.
Recent work in Hong Kong, primarily on landscape amelioration, is also referred to. Social, cultural, research issues are also discussed as well as obstacles to and pitfalls in the adoption of bioengineering methods. As an example, unless great caution is adopted, together with ability to deliver efficient aftercare and control, the use of exotics and monocultures should be avoided if at all possible. An example of the ‘solution’ of one generation of workers turning into the ‘nightmare problem’ of succeeding ones is mentioned.

Other issues referred to include the conflicts which can arise between the prescriptive approach necessitated by organizational and project scope considerations on one hand and the need to respond to each site with its unique combination of slope geometry, surface and sub-surface drainage soils in order to harness effectively the functions of plants and of ecosystems generally.

Paper Abstracts (2)

Ecological Greening

Ken K Y So [1] and Billy C H Hau [2]

[1] Flora Conservation Department, Kadoorie Farm and Botanic Garden
[2] Department of Ecology and Biodiversity, The University of Hong Kong

The concept of ecological greening (eco-greening) was developed in the 1980s. By using potential naturally occurring plant species, the planted vegetation can be easily linked with the surrounding natural vegetation, and thus will integrate better with the natural ecosystem in the future. The main advantages of eco-greening are low construction and maintenance costs. It is because seedlings rather than standard trees (higher in cost) are preferred for the better establishment and development of healthy root systems. In addition, as the planted vegetation is integrated with the natural ecosystem, nature will take over the management role eventually after 2 to 3 years. The expectations on the ecological functions of greening -- both in afforestation and urban landscaping have been rising as a result of increased awareness of environmental protection and conservation in Hong Kong. In addition, due to the shortage of lands, urban development has been expanding to the countryside. For greening projects in urban-countryside transition areas, not only will eco-greening beautify the environment, it will also provide a functional ecosystem for local wildlife. The key to eco-greening is to use suitable native plant species to encourage the succession process. By summarizing the observations of some native tree planting works in Hong Kong these years, a list of potential native tree and shrub species suitable for eco-greening is suggested in this paper.

Paper Abstracts (3)

The Use of Soil Bioengineering Measures to Repair Selected Natural Terrain Landslides in Hong Kong

S D G Campbell[1], R Shaw[1], P A Chao[2], A Dias[2] and Robbin B Sotir[3]

[1] Geotechnical Engineering Office (GEO)
Civil Engineering and Development Department,
[2] Maunsell Geotechnical Services Limited
[3] Robbin B. Sotir & Associates, Inc.

In 2003, the GEO commenced an innovative project to study and trial soil bioengineering measures on natural terrain. The project was designed to identify measures with the potential to minimize natural slope deterioration, reinforce the soil mass, and improve resistance to debris movement. Soil bioengineering is perceived as a low-cost, environmentally compatible, and sustainable alternative to conventional engineering methods. Although not a “greening” project, the measures are compatible with greening initiatives.

Five sites were identified to test the applicability and performance of the selected measures. Potentially applicable measures for repairing failed/distressed natural hillsides were reviewed. The sites were assessed using API, followed by geomorphological mapping and vegetation surveys. In consultation with local experts, suitable plant species and species combinations were identified. The selected species are mostly native, but some exotics were also included.

Soil bioengineering measures were designed and applied in various combinations at the Cloudy Hill North pilot site. These measures will be described. Planting was carried out using vegetative cuttings, material harvested around the sites, and rooted nursery seedlings. Planting in 2004 served as a trial for further sites in 2005, generating valuable baseline data on topics such as species tolerances, methodologies, and cost-effectiveness. Monitoring of the performance is continuing, but initial results will be presented.

Importantly, the findings are being documented to provide guidance on how to apply soil bioengineering measures to other sites in Hong Kong. An outline of the contents will be presented.

Paper Abstracts (4)

Slope Surface Protection with Natural Succession

Albert N L Ho[1] and Noriman S C Mak[2]

[1] Ove Arup & Partners Hong Kong Limited
[2] Hong Kong Construction (Civil Engineering) Limited

The slope surface protection industry thrives to balance between the needs for engineering functionality and environmental sustainability. The ideal slope surface for man-made slopes therefore has to exhibit dual properties that satisfy the engineering and the ecological fundamentals of a slope face. While the micro-climate for a slope surface needs to be considered, an overall macroscopic approach is fundamentally important to provide a total solution in achieving sustainability on man-made slopes.

The balanced philosophy using an Eco-engineering approach will involve the appropriate selection of engineering methodologies on stabilization of slopes that is important towards a safe and stable slope. It also considers the ecological aspects with appropriate initial vegetation settings specific to that slope area to encourage natural succession, aiming at restoring ecosystems and blending with the natural surroundings for sustainability.

The availability of an environmental surface protection layer using Continuous Fiber Reinforced Soil method (Geofiber) that is strong and stable for the severe Hong Kong climate in nurturing natural succession and biodiversities of plant communities on man-made slope surfaces has propounded new dimension to the slope protection industry. The stable natural Geofiber substrate therefore serves as a stable reference base in the study of natural succession of plant communities on man-made slope surfaces using the Eco-engineering approach proposed.

This paper presents a typical sustainability case study using the proposed Eco-engineering approach for a project at Tsing Yi carried out more than 3 years ago. Observations and data gathered to date have already shown the transition taking place from the initial design habitat to a more diversified natural community on the slope face, while maintaining at all times, the safety and stability of the slope face.

Paper Abstracts (5)

Biodiversity Recovery in Exotic Tree Plantations on Man-made Slopes in Hong Kong

Ida M Y Yu and Billy C H Hau

Department of Ecology and Biodiversity
The University of Hong Kong

There are about 57,000 registered man-made slopes in Hong Kong and some of which have been planted with exotic tree species. In order to assess the extent of biodiversity recovery in such restored habitats, three 10 - 20 year old man-made slopes covered with *Acacia confusa* plantations were studied for the understorey floristic and soil invertebrate diversity. Two 30 - 50 year old secondary forests were also studied as references. In the floristic survey, the non-metric MDS ordination showed a distinct group difference between plantations and natural forests in the understorey plant community. The understorey plant diversity of natural secondary forest was significantly higher than that of exotic plantations on man-made slopes. The presence of some pioneer secondary forest species on man-made slopes suggests that there are natural seed sources in these plantations for natural regeneration to proceed. However, the generally small size of these naturally occurring tree and shrub seedlings suggest that the rate of natural regeneration is very slow. In the soil invertebrate survey, the non-metric MDS ordination showed no clear distinction between the two vegetation types. This implies that soil invertebrates may be able to colonize exotic plantations faster than plants. The results of this study shows that management improvement measures such as thinning of the exotic tree canopy or enrichment planting of native tree species are needed to promote natural regeneration on man-made slopes covered with *Acacia confusa* trees.

Paper Abstracts (6)

A Review of the Field Performance of Native Tree and Shrub Species Planted on Man-made Slopes in Hong Kong

Billy C H Hau[1] and Ken K Y So[2]

[1] Department of Ecology and Biodiversity, The University of Hong Kong
[2] Flora Conservation Department, Kadoorie Farm and Botanic Garden

The traditional landscape treatment on gentle man-made slopes (slope angle < 45°) in Hong Kong using exotic grass and tree species has been criticized as not eco-friendly in recent years. More native species should be used, especially on those slopes inside nature reserves, so as to enhance the ecological performance. Many planting trials using native trees and shrubs have been conducted in the last few years but not much published information is available. This study was set out to review the performance of native tree and shrub species used in 4 different slope planting projects in Hong Kong. The slopes in Tai Lam Country Park and Kowloon Reservoir are situated inside or adjacent to country parks and are better protected from wind and other disturbances. The other two slopes in Homantin and Shek O are more exposed and in windy sites. A total of 26 tree and shrub species were used in these 4 slopes. Seedling survival and growth rates are much better in the Tai Lam slope. Survival rates in the other three slopes are not well especially in Shek O (except in one of the 4 plots that are better protected by the surrounding vegetation). Overall seedling performance appears to follow the decreasing quality of the slopes for plant establishment. The overall performances of the 10 Fagaceae species used (except *Lithocarpus corneus*) are very satisfactory. In high quality site (Tai Lam), the growth and survival rates of the Fagaceae species are very good. Even in low quality sites (Homantin and Shek O), the survival rates are acceptable though the growth rates are low. Apart from those native species that have been reported to perform well in previous planting trials such as *Melastoma sanguineum* and *Schefflera heptaphylla*, other species that perform well from this review include *Alangium chinensis*, *Bridelia tomentosa*, *Machilus breviflora*, *Reevesia thyrsoidea*, *Syzygium hancei*. It is recommended that these species should be put to more systematic trials to confirm if they are suitable for planting more widely on man-made slopes in Hong Kong.

Paper Abstracts (7)

Fundamental Problems of Growth Substrates on Bioengineered Slopes in Hong Kong

K C Chau

Department of Geography and Resource Management
The Chinese University of Hong Kong

This paper examines the performance of nine commonly adopted slope bioengineering techniques in Hong Kong, with special emphasis on their substrate properties and vegetation characteristics after less than 1 to 4 years of establishment. Altogether 17 slopes were investigated and they were broadly categorized into soil-based systems and mulching systems. The physical properties of these substrates, including thickness, compaction and bulk density, were highly heterogeneous within and among the different slopes. The limited thickness of substrates ranging from 5-26 cm constrained the rooting depth and storage capacity of water and nutrients for vegetation establishment. Moisture supply in the substrates followed closely the pattern of incident precipitation in the absence of irrigation. The chemical properties of the substrates were equally heterogeneous and many of them were deficient in N and P. The mulching systems were dominated by peat materials and contained higher organic matter, TKN, mineral N and P, and cation nutrient levels than the soil-based systems. Many of the substrates yielded wide C:N ratios, suggesting slow mineralization rates and the likely imbalance of nutrients. While exotic grass and shrub species were the dominant vegetation on these slopes, the green cover dropped by more than 50% between the wet and dry seasons. The causes of this problem were discussed, with specific reference to substrate composition and the philosophy of low maintenance inputs. A few rules were identified in the selection of growth substrates suitable for use on bioengineered slopes in Hong Kong.

Paper Abstracts (8)

The Paradoxical Role of Water in Slope Bioengineering

Francis C H Wong[1], K C Chau[1] and L M Chu[2]

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The Chinese University of Hong Kong
[2] Department of Biology, The Chinese University of Hong Kong

Water in the form of precipitation, surface runoff or groundwater is a vital factor governing slope safety in view of the large number of landslides that had occurred between the 1970s and 2000s. All slope stabilization measures should improve water flow and cater for the uncertain change of groundwater level. The purpose of these measures is to restrict water to a desirable level, including the installation of horizontal drain and the diversion of surface runoff.

Water catalyses the weathering of parent rocks belowground and weakens the slope to an unsafe condition as a result of micro-alteration and/or macro-lateral pressure in the rock mass. The common solution to alleviate the adverse effects arising from the presence of water is to let it drain. To do this, we need to know the hydrological characteristics belowground.

The design and establishment of an effective water discharge system is not only the basis for slope stabilization works but also the key to sustainable slope bioengineering. One objective of existing greening techniques is to enhance the input and retention of water on slopes by adding drain mat, safeguarding impermeability of the barrier layer and increasing porosity of the growth substrates. This paper revisits the concepts of slope water and its paradoxical role in achieving safe and green slope. Specifically, current practices catering for slope water in association with slope stabilization works and sustainable slope bioengineering will be reviewed.

Paper Abstracts (9)

Nutrient Analyses of Organic Fiber Soil for Slope Greening in Hong Kong

Xiao-Yun Mao[1], Wai-Lun Tan[2], He-Rong Guo[1], Tai-Pui Ho[2] and Zong-Wen Liao[1]

[1] School of Resource and Environment, South China Agricultural University
[2] Toyo Greenland Company Limited

Organic hydromulching system, which is a green technique with no/low maintenance and can provide a self-sustainable plant cover, has been utilized on over 120 numbers of man-made slopes in Hong Kong for the past 6 years. In this study, vegetative establishment and characteristics of the substrate, called Organic Fiber Soil, were examined and analyzed on 14 selected slopes that were applied with this technique throughout the past 6 years. The results of vegetative establishment showed that: Biomass varied throughout the completion year; however, biomass on each slope was relatively higher than that of grassland. Communities on these vegetation systems were dominated by planted species. Green coverage provided by this technique was satisfactory and the total covers on most slopes were over 90%. *Wedelia trilobata* and *Macroptilium atropurpureum* were the dominant and subdominant species, respectively. The results of the substrate's characteristics showed that: the trend of pH value reached neutral and there was a decreasing trend of soil hardness. The abilities of the substrate to absorb and retain water were maintained for over 6 years, while there was no significant erosion of the substrate. The concentration of organic matter decreased in a slow rate as the completion year increased. The concentration of total nitrogen did not vary while that of both total phosphorus and potassium increased. A cycle of plant-available nitrogen was observed with the concentration decreased and then increased afterwards.

Paper Abstracts (10)

Revegetation of Man-made Slopes from a Maintenance Perspective

Eric W K Chan

Highways Department, HKSAR Government

Since 2004 Highways Department has been assigned by the Environmental, Transport and Works Bureau (ETWB) to maintain vegetation on registered slopes under the Department's jurisdiction. As many of the man-made slopes were resulted from infrastructure development alongside of carriageways, Highways Department is required to maintain about 10,000 registered slopes with total area of more than 11,000,000 m^2. About 75% surface areas of these slopes are soil surface with vegetation while the rests are rock slopes and slopes with shotcrete or other forms of impermeable surface treatment where maintaining a soil surface is impractical in geotechnical term. The majority of the vegetation on existing slopes is covered by fast growing exotic species planted for their quick establishment and vigorous growth under unfavorable conditions as nursery species. Apart from maintaining the slope vegetation in a green, safe and hygienic condition, some exotic trees have to be cleared for the visual inspection of geotechnical engineering elements and to allow for the growth of native species.

For planting design of newly formed slopes, it is critical to achieve a self-sustainable vegetative cover with mixture of exotic and native species. Major considerations in the selection of plant species include; geotechnical aspects, physical constraints, ecological issues and public demand for a green environment are basic considerations for future horticultural commitment.

In the last few years, different proprietary greening systems have been tried for establishment of vegetative cover on rock and shotcrete slopes as a greening initiative. The performance of these slopes indicated that most of them are suitable for specific location with intensive maintenance support. Application of mulch or other kind of growth media onto impermeable slope surface is never a good way to green roadside slopes to harmonize with the environment. The simplest greening solution to a sterilized slope is to eliminate it in the design stage. It is important to understand that engineering and landscape solutions are not developed in isolation from each other, but as part of an integrated process[2].

[1] Registered slopes refer to features registered in the Catalogue of Slopes (i.e. the "Systematic Identification of Maintenance Responsibility of Man-made Slopes in Hong Kong" – SIMAR study) stipulated in the Environment, Transport and Works Bureau Technical Circular No. 26/99

[2] GEO Publication No. 1/2000, *Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and retaining walls*, Geotechnical Engineering Office, Civil Engineering Department, The Government of the HKSAR, pp.21.

Paper Abstracts (11)

Green Revolution: Is there any Panacea for Slope Landscaping?

L M Chu

Department of Biology, The Chinese University of Hong Kong

Stability and landscaping of man-made slopes that are liable to geotechnical failure has been a major concern in Hong Kong. However, the issue is more often engineering-oriented and the emphasis is on the creation of an instant greening effect. There is a significant gap between the art and science of slope landscaping. We are limited by the choice of species available for use in slope revegetation. Drought is thought to be the most limiting factors for plant growth. Belowground performance is a black box. The substrate used is heterogeneous and the layer added on cutslopes is usually thin which restricts root development and moisture retention. Loss of nutrients via surface and subsurface runoff can be severe as the gradient increases. There is also the problem of soil loss due to wash away by heavy storms. Recurring recession of the sward soon after establishment is not uncommon, and unsustainability seems to be the major problem confronting the local slope greening industry.

Selection for vegetation that can thrive under conditions prevailed on slopes is an effective approach to the problems. Herbaceous vegetation is more effective in intercepting rainwater and preventing soil detachment and water runoff, which are the results of water removal and mechanical reinforcement by their roots. Perennial species should be preferred to annuals. Herbaceous legumes which can fix atmospheric nitrogen are also beneficial. Species that resist drought, produce shallow but extensive roots, and give high shear strength are the most suitable. However, the sole reliance on only a few exotic species results in the creation of habitats that are not conducive to biological diversity and nature conservation. Suitable plant species must be able to establish, grow well and perform the required functional role on slopes. Invaded species may outcompete sowed grasses and there is much to learn from the successional ecology on slopes. Regarding hardware, simple erosion control mat and soil nails could enhance slope stability. If cost is permitted, irrigation should be done to improve plant growth in dry spells and to guarantee sustainable vegetation development on slopes.

Poster Abstracts (1)

Slope Bioengineering in Country Parks

C K Chan

Agriculture, Fisheries and Conservation Department
HKSAR Government

Past experience in hydroseeding of engineered slopes showed that there appeared to be a succession of growth of grass vegetation on the slope over the seasons. The dominant grass species will eventually control the appearance of slopes, which is usually the native species. Experience to date in Agriculture, Fisheries and Conservation Department (AFCD) suggested that a minimum period of 3 to 4 years would be required for the establishment of a reasonably stable vegetation cover on disturbed slopes in country parks. The cheap and conventional method of hydroseeding with provision of a layer of erosion control mat (and provision of wire mesh where required) might prove to be successful in the context of restoring natural vegetation on man-made slopes in country parks. The more expensive greening system on slopes may not be necessary in the country park setting. Because of various animal activities inside country parks, extra effort is required to safeguard the delicate growth of grass, shrubs and small trees during the initial growing period soon after hydroseeding and planting.

Poster Abstracts (2)

The Live Pole Technique for Slope Stabilisation

David H Barker

Prima Subur Sdn Bhd, Kuala Lumpur

The poster paper describes the live pole technique for slope stabilisation. This is a recent introduction to the 'conventional' range of bioengineering applications of large section hardwood cuttings. This involves the installation of closely spaced vertically orientated arrays of large diameter live poles typically 45-85mm diameter and 2-3m long. These can be installed as retro-fitted slope stability enhancements at post slope construction stage into suspect and failed engineered fills, and natural slopes and formed and failed cuttings with deep weathered surface soils.

Live hardwood cuttings of selected species – usually willow (*Salix* spp.) or poplar (*Populus* spp.) - have been as live wattles or fascines and brushlayering. The paper describes how the former act primarily as surface flow retarders or energy breaks to control slope erosion and the latter combine this function with advantages of stiff shoulder reinforcement and horizontal groundwater drains, whilst wattles are also usually installed into slopes after construction. Brushlayers also can be installed as retro-fits into failed and suspect slopes, but they are usually installed during construction of engineered fills. For both techniques, subsequent root growth enhances shear strength of adjacent soil and thus the stability of adjacent slope zones.

The live pole technique shares all these attributes with the advantage of a deeper-seated effect due to their significantly greater penetration when used in retro-fitted mode into existing slopes.

The paper illustrates principles behind the design and construction of a typical live pole slope stabilization installation, with tabulated brief details of research and pro-active maintenance projects in Europe, USA and the Seychelles.

The paper proceeds to describe the potential for use of live pole technique in tropical and sub-tropical regions utilizing indigenous woody species with similar vegetative propagation and rapid growth characteristics.

Poster Abstracts (3)

Soil Water Supplying Capacity as a Factor Affecting Vegetation Growth on Man-made Cutslopes

M H Chiu[1] , K C Chau[2] and L M Chu[1]

[1]Department of Biology, The Chinese University of Hong Kong
[2]Department of Geography and Resource Management
The Chinese University of Hong Kong

Currently, there are 57,000 man-made slopes and retaining walls registered in Hong Kong, which are created as a result of city development. These slopes are susceptible to erosion and landslide, and may pose great danger to the public. Recently, many proprietary systems have been developed for the greening of cutslopes in addition to providing the stability factor as shotcrete did in the past. However, these systems have thin soil layers and steep slope gradients, leading to limited infiltration and storage of water in the soil. As a result, the availability of water to soil and plants, and hence drought, may be a problem for these systems. Therefore, the objectives of this experiment were to determine the soil water status and substrate properties of selected proprietary slope revegetation systems. The seasonal variation of various soil parameters and their relationship to vegetation growth were also examined.

Soil moisture of the proprietary systems was affected by the amount of rainfall to a very great extent. In general, soil moisture was over 10% in wet season, but less than 2% in dry season for most systems. Accordingly, green coverage for all systems increased in summer but declined dramatically in winter. Soils of the various systems had adequate amount of TKN, TP and major extractable cations but low mineral N and available P, and there was no significant difference in nutrient levels between the wet and dry seasons. Soil water supplying capacity appears to be the major factor affecting plant performance of these systems. Higher organic matter content and lower bulk density accounted for the higher available water capacity in mulch-based substrates when compared with soil-based ones.

Poster Abstracts (4)

Vegetation Performance on Cutslopes

C W Chong and L M Chu

Department of Biology
The Chinese University of Hong Kong

Cutslope greening has become more important regarding the number and nature of slopes, government policy and business opportunity. Landscaping techniques available can definitely provide an instant greening effect. However, there is no information on the long term vegetation growth on such slopes. In the present study, nine commonly used slope greening proprietary systems were evaluated for their vegetation growth and species colonization. Over 50 slopes of age <5 years old and angle >45^{o} were selected. Vegetation analysis in terms of species composition, number, abundance and coverage was done twice a year from 2004 to 2005 to provide both annual and seasonal data.

Regardless of the techniques used, the studied slopes could be categorized into two types according to their original vegetation, namely Wedelia-based or grass-based. Both types of slope developed differently. Though species recruitment in terms of species number and diversity could be very similar for both types of slope located adjacently, the coverage of invaded species was much lower in the Wedelia-based slopes than in the grassed slopes, especially during the growing seasons. On the other hand, the hydroseeded grass such as bahiagrass and bermudagrass were sparsely present on the grassed slopes, while weeds such as *Mikania micrantha*, *Ageratum conyzoides*, *Conyza bonariensis*, *Chloris barbata* and *Rhynchelytrum repens* dominated. Seasonally, most vegetation wilted in the dry months, regardless of the slope types, proprietary techniques or planted vegetation. Nevertheless, most of the slopes recovered and became green again in the growing season. Yet the extent of recovery depended on factors such as the proprietary technique, original vegetation type and potential seed source. Slopes that were once invaded by weed species were able to recover more vigorously in the summer.

Poster Abstracts (5)

Slope Greening – Its Challenges to the University Campus

Francis C H Wong

The Chinese University of Hong Kong

With an area 17 times that of Hong Kong Park, the Chinese University's 134-hectare campus is the largest in Hong Kong. The latest satellite pictures provided by the Joint Laboratory for Geoinformation Science indicate that nearly 80 per cent of the campus is covered by vegetation which has been established in association with the development and stabilization works during the period from 1963 to 2005.

Since 1997, greening, besides safety, has been the main concern of slope stabilization works at the University. Different greening techniques have been implemented on these slopes. Over the years, the greening performance in different slopes reveals the complexity of factors affecting the effectiveness of the techniques. To develop a mature, safe, environmentally-friendly and cost-effective greening technique, it normally goes through different stages: technology transfer, trial panels for performance review and implementation. Since 1998 the University invited practitioners to set up their unique methods. Under similar slope conditions, this provides a good performance reference for different techniques and lead to research and development studies in different academic departments.

Slope bioengineering becomes a trend in recent slope stabilization works, focusing on slope vegetation, planting of native species and preserving biodiversity. Several slopes on campus indicate the need of "tailor-made" design for specific slope conditions to optimize the growth of vegetation.

Field Visits

Coordinator: Ir Francis C H Wong

Field Illustrators:	Ir Francis C H Wong	(Group 1)
	Mr Arthur W T Ma	(Group 2)
	Mr James Y F Man	(Group 3)

Introduction

There are 3 themes in the field visit session:

- **R & D on Slope Bioengineering** – Introduction of facilities and equipment on campus for research and development in either academic or industrial trials, including rainfall stimulators and greenhouse.

- **Greening Techniques and Trial Panels** – Many greening techniques implemented in Hong Kong were established on campus in the late 1990s, to assess their sustainable performance. Some of them were set up in 1998 and modified gradually based on the observation noted. Selected greening techniques are used for academic study.

- **Case Studies** – Visit slopes where greening techniques or general landscaping works had been applied, taking into account environmental harmonization, site constraints and the need of integrative approach.

Grouping and Routing

Group	Start at	Stop at	Dismiss at
1	S1	S2 to S8	S9
2	S3	S4 to S8, S2 to S1	S9
3	S8	S7 to S3, S2 to S1	S9

S1: Cut slope (CR17)

Colluvial deposits with boulders up to 3 m in diameter, stabilized with soil nail and covered by shotcrete to cater for high groundwater level and intensive surface runoff; hard landscaping of stone pitching, planters and tree rings.

S2: GRM Greenhouse and rainfall simulators

Demonstration of rainfall stimulators and ancillary facilities for slope erosion study; growth of common Bermuda Grass on sludge-amended DG, and potted experiments on nitrogen requirement of native tree species.

S3: Trial panels on slope bioengineering studies

Principles and objectives of selected slope greening techniques on campus.

S4: Cut slope and disturbed terrain (C104 & DT28)

A landslide scar formed in 1997, stabilized with a combination of soft and hard landscaping techniques including planters and erosion control mat. Note naturalness of the established slope and vegetation.

S5: Greening techniques (C2)

Trial panels established since 1998. Note their design, substrate composition, performance and maintenance requirements. What lessons have we learnt from these trial panels?

S6: Rock cut slope (CR4)

A rock cut slope with plenty of colours; use of soft and hard landscaping techniques only; rock face also an important component of landscaping.

S7: Soil/Rock cut slope (C274)

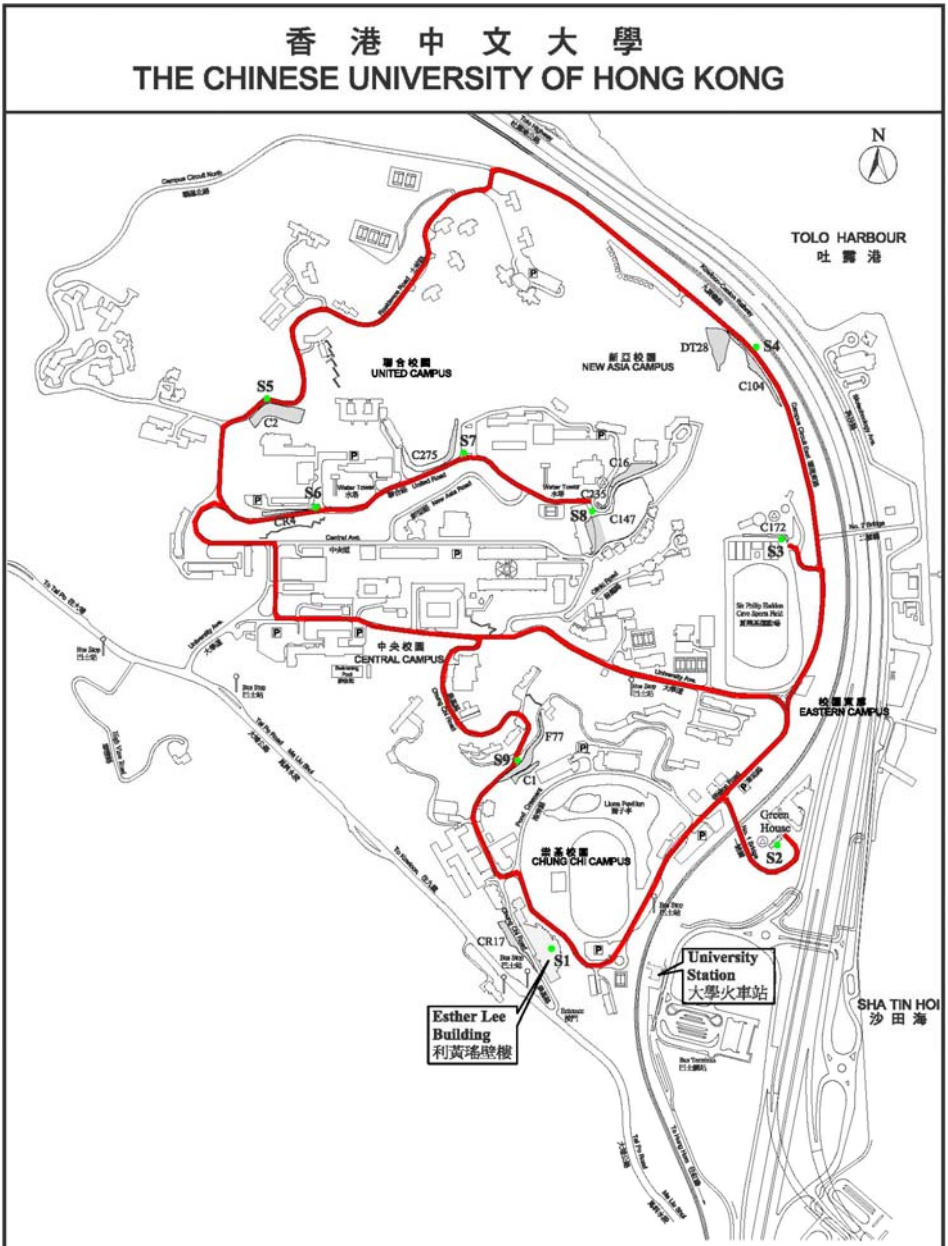
Soft and weathered dyke rock across the slope, stabilized by soil nails and shotcrete. Fibred soil was applied to support vegetation growth and the established slope is sub-vertical and dry.

S8: Soil/Rock cut slopes (C147 & C16)

Fibered soil applied to two cut slopes at different time. Re-planting had been carried out on C16, involving a change of planting materials and close monitoring thereafter. Note the different performances of these slopes.

S9: Fill and soil cut slopes (F77 & C1)

Slope stabilization works completed in 1999, involving re-compaction and remedies of geotechnical difficulties. Erosion control mat and shade seem to have no adverse effect on the vegetation. Note the invasion of species taking place on these sites.



ROUTING AND LOCATION PLAN
FIELD VISITS FOR WORKSHOP ON CONCEPTS AND PRACTICES ON SLOPE BIOENGINEERING

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Acknowledgements

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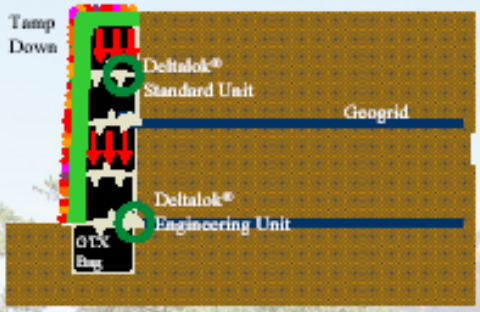

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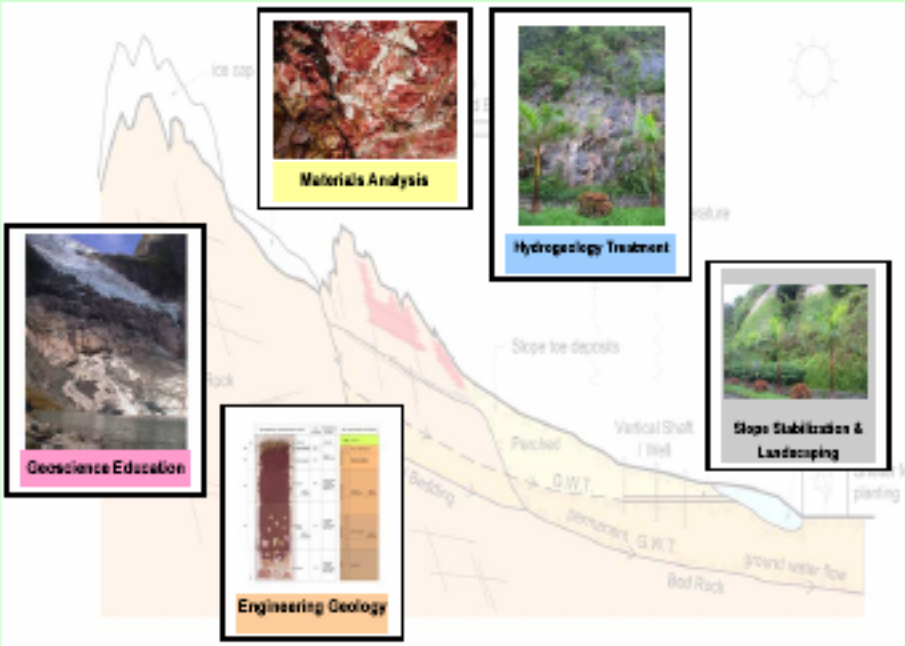

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