Session 7
Global Approach to Slope Safety in Hong Kong (Part 1)

[1:00 – 3:00 pm, 19 February 2009]

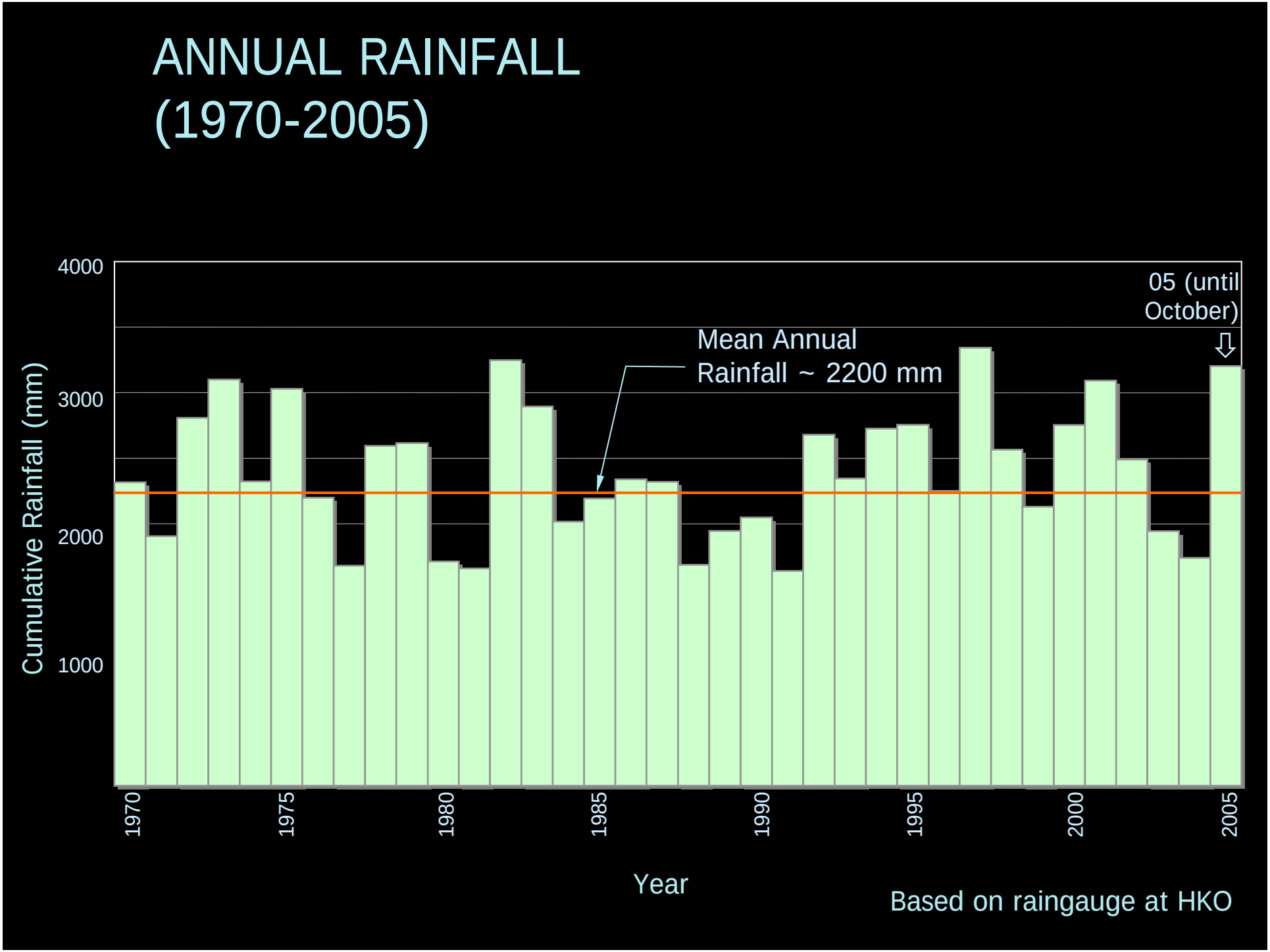
Dr. H.K. Tam

Geotechnical Engineering Office

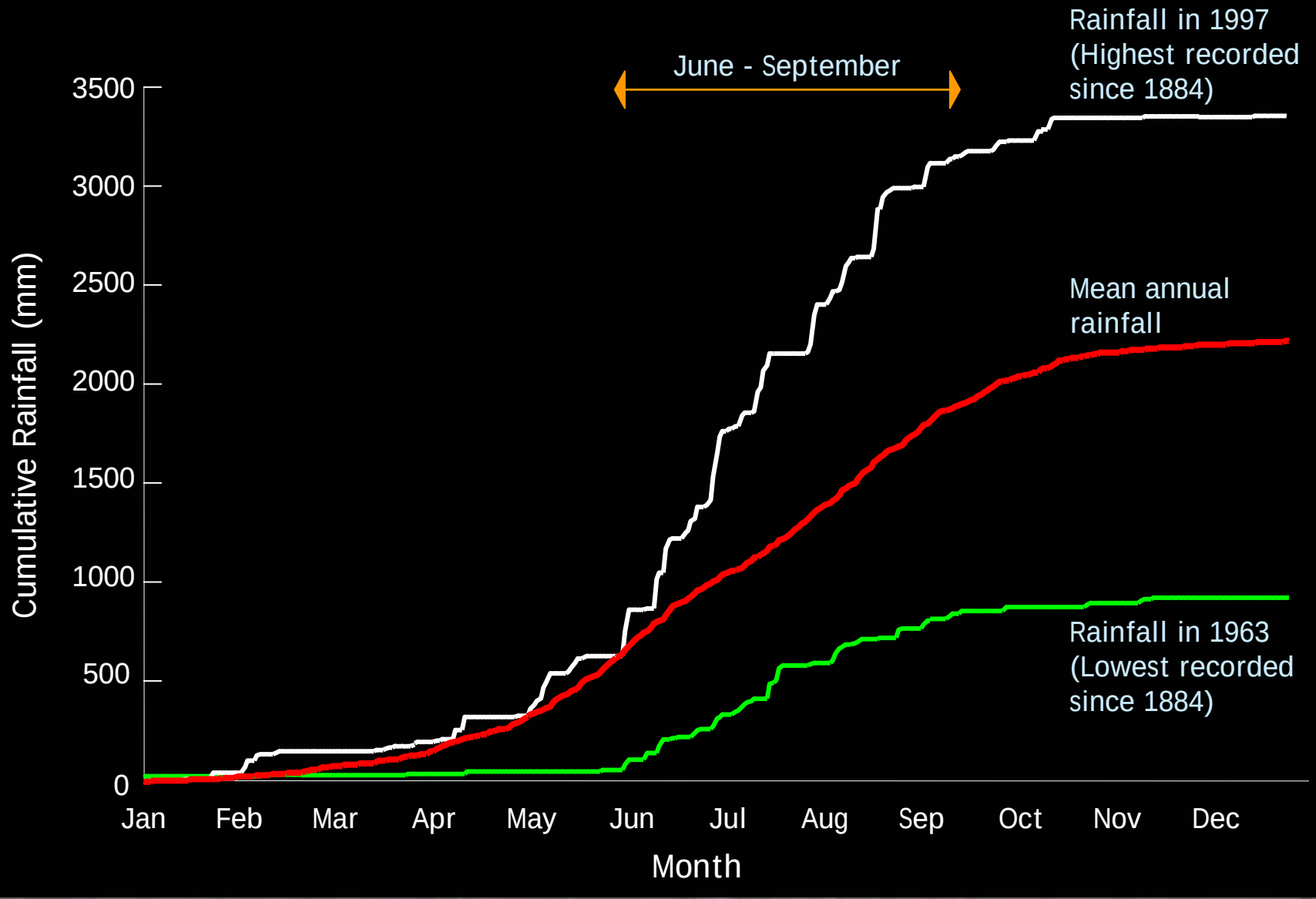
Objective of this session:

- Slope safety in Hong Kong in early years
- Set up of the geotechnical control mechanism
- The Key Result Areas of the Hong Kong Slope Safety System
- Aesthetic treatment of slopes
- The landslip prevention programmes

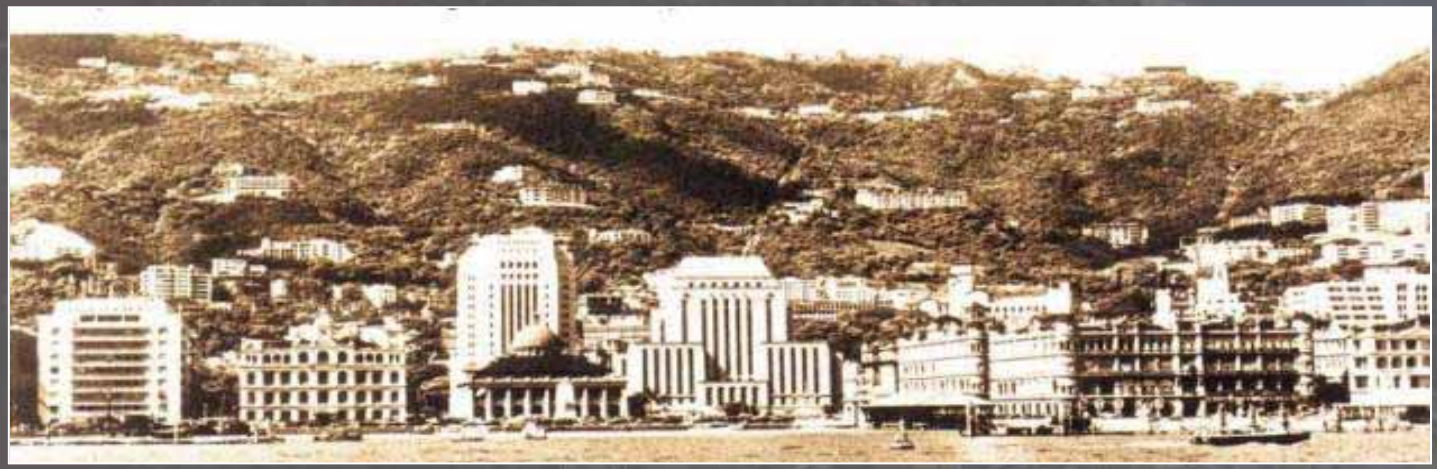
ANNUAL RAINFALL (1970-2005)



YEARLY RAINFALL DISTRIBUTION



Urban slope engineering and landslide risk management



1900

2000

… essential to sustainable urban development on Hong Kong's hilly terrain

Evolution of Slope Engineering and Landslide Risk Management in Hong Kong

Mid-1990s

Enhanced Landslide Risk Management

Fatal Landslide 1994

1977

Geotechnical Slope Engineering

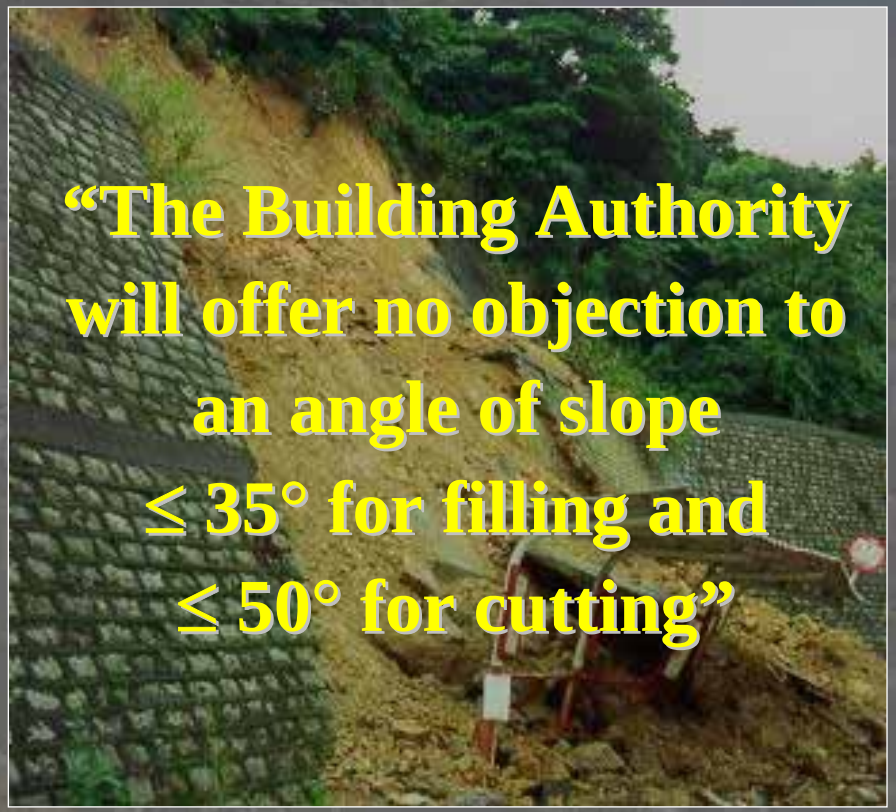
GEO set up

Empirical Slope Engineering

Fatal Landslides 1972 & 1976

Pre-1977: Empirical Slope Engineering (Prescription based on Rule-of-thumb)

Rapid urban development after WWII, with little geotechnical input and construction control



"The Building Authority will offer no objection to an angle of slope
≤ 35° for filling and
≤ 50° for cutting"

... although it works in some cases, it fails where the ground is 'atypical', and when heavy rain comes

Many landslides in the old days

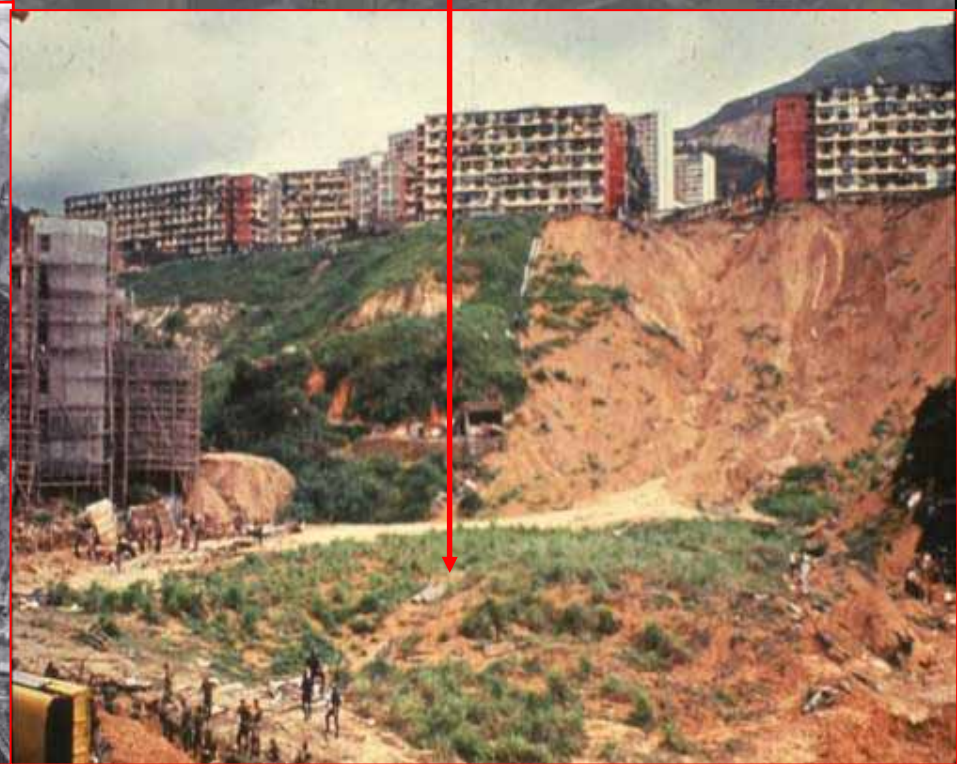
… part of Hong Kong people's struggle for living

1972 Po Shan Landslide
(Vol. = 20,000 m^3 ; 67 fatalities)

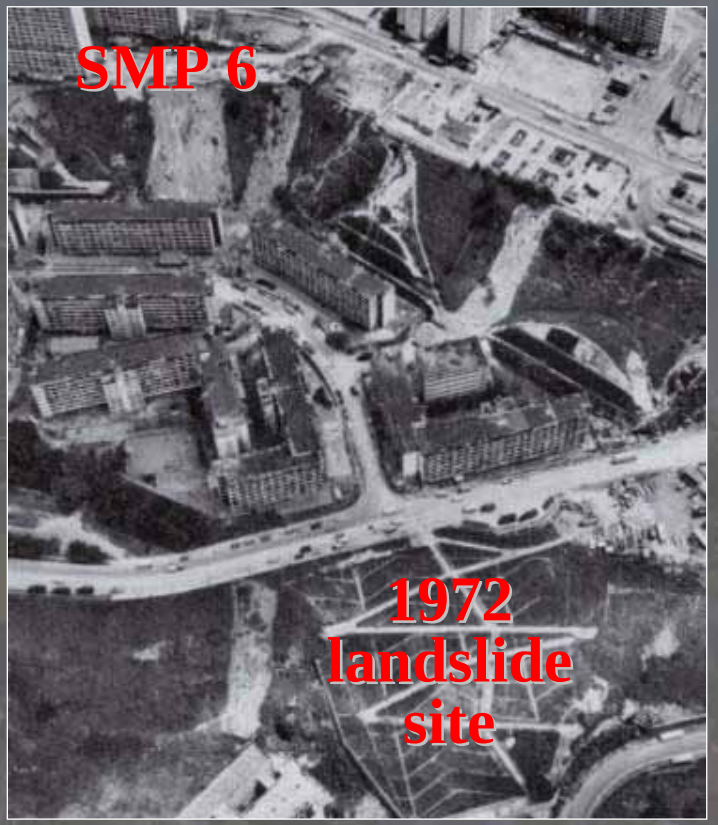
1972 Sau Mau Ping Landslide

(Vol. = 6,000 m^3 ; 71 fatalities)

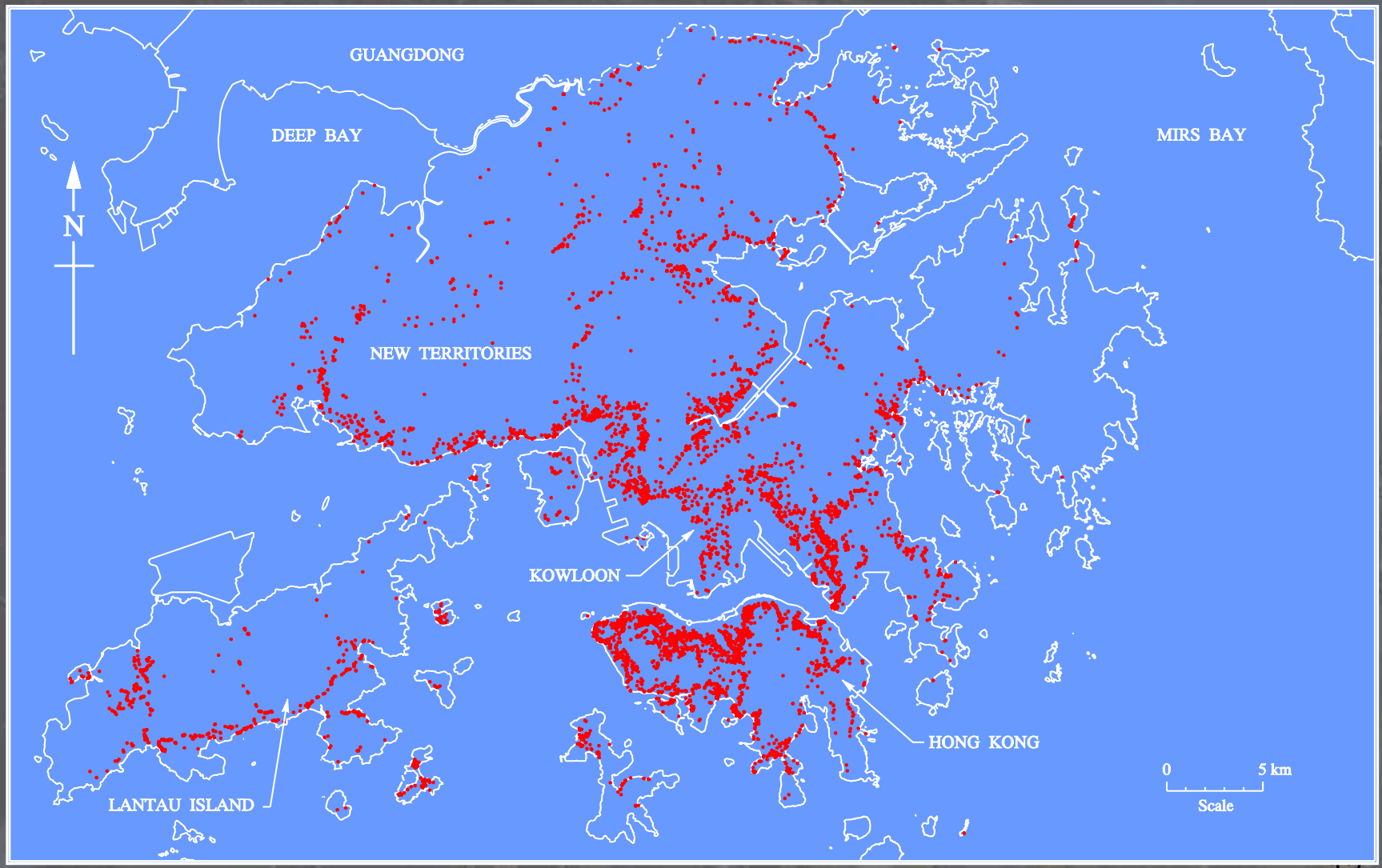
Fill slope mobile failure



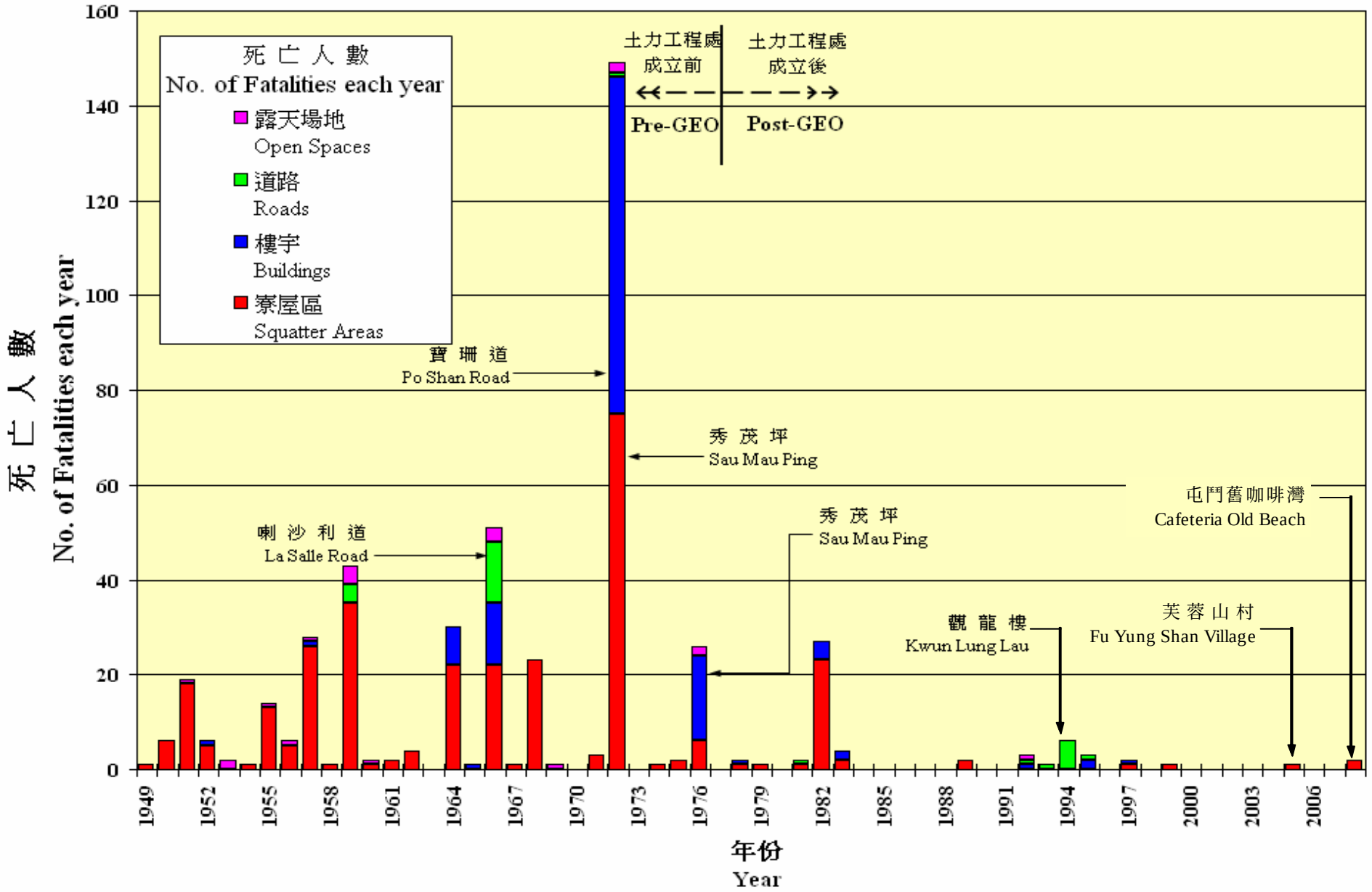
1976 Sau Mau Ping Landslide
(Vol = 5,000 m^3 ; 18 fatalities)



Spatial Distribution of Landslides Reported to GEO in the Period 1982-2004



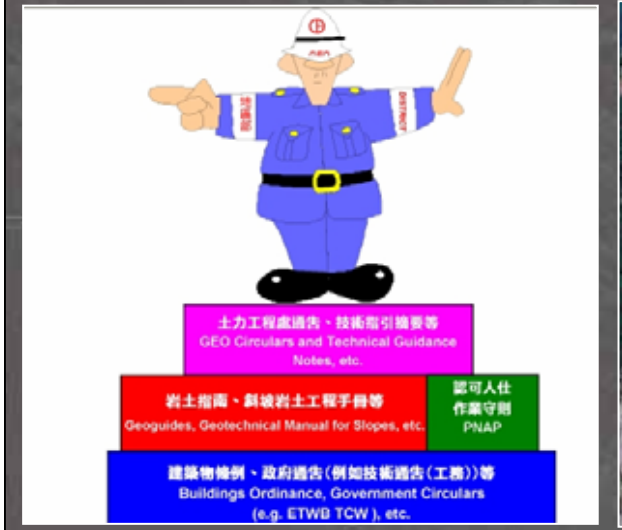
因山泥傾瀉而導至死亡的人數
Known Landslip Fatalities in Hong Kong



Set up of Geotechnical Engineering Office in 1977

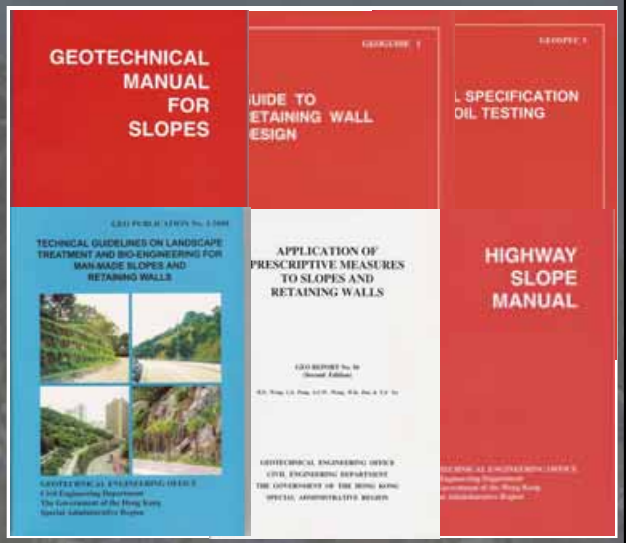
- On the recommendation of an independent review panel, the Geotechnical Engineering Office (GEO) was established in 1977 to regulate slope safety in Hong Kong.
- The key issue is how to ensure the safety of new slopes and to reduce landslide danger of existing slopes.

Strategies of GEO in 1977



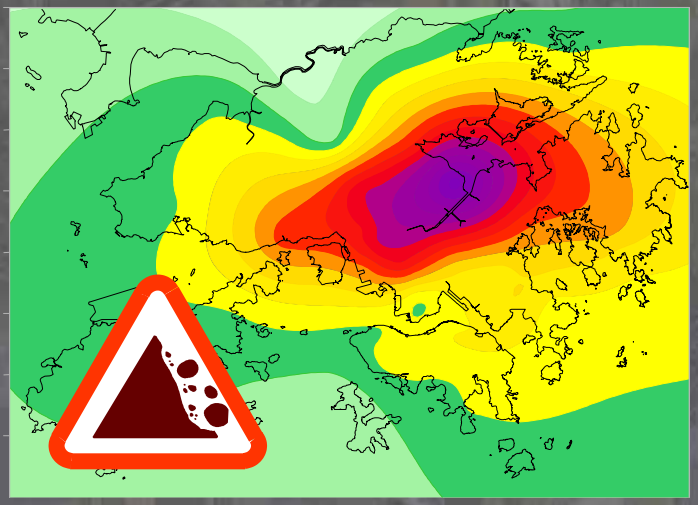
Geotechnical Control

Landslip Preventive Measures Programme



Setting Standards

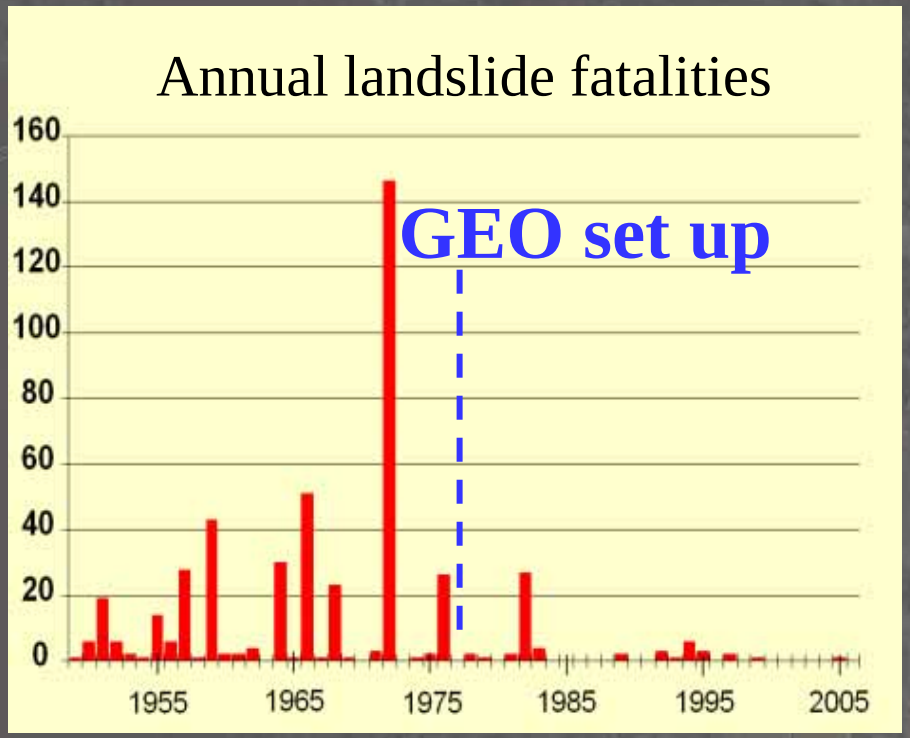
Squatter Clearance



Landslip Warning

Land Use Planning

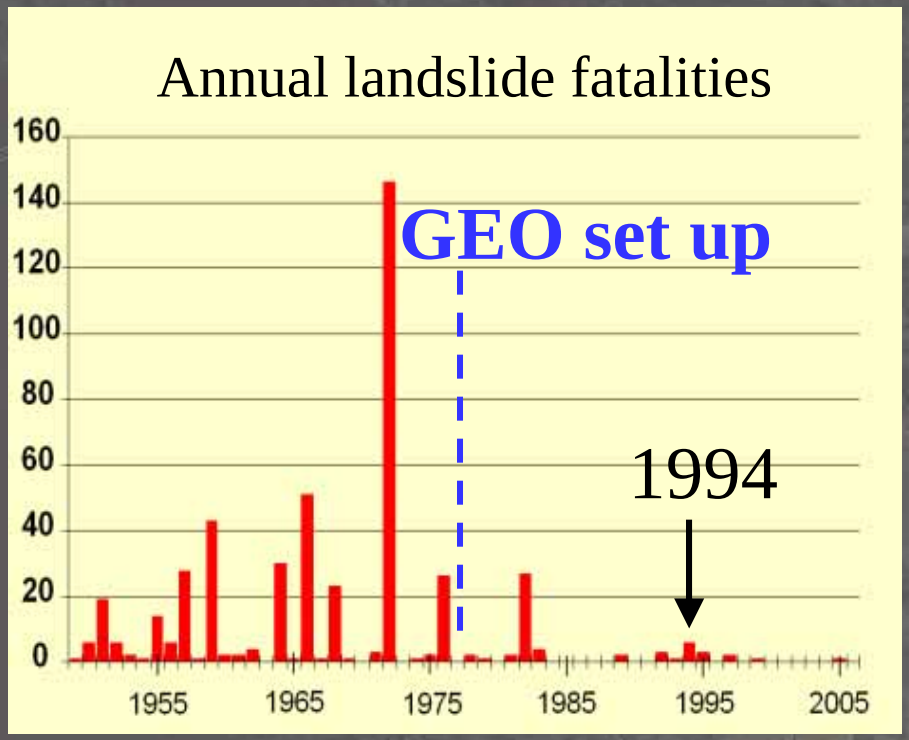
Annual Landslide Fatalities in Hong Kong



Number of fatalities have been much reduced since the setting up of the GEO in 1977

1994 Kwun Lung Lau Landslide

(Vol. = 1,000 m^3 ; 5 fatalities & 3 injuries)



- Collapse of an >100-yr old masonry wall, owned by NGO
- Affect a footpath (temporal users)
- Much smaller in scale of failure, occurred during landslip warning

Great outcry from the public, politicians and Administration

Slope safety criticised

Separate inquiry on landslide demanded

Faults revealed in monitoring of dangerous slopes

By KEITH WALLIS

GAPS in the way slopes are monitored were revealed last night by a senior government official.

Plans to move bus stops away from potentially dangerous slopes could have been speeded up, said the Deputy Commissioner for Transport, Pang Hau-chung.

This was despite the programme being given priority by the Geotechnical Engineering Office (GEO) following a landslip in June last year which killed a 37-year-old woman and injured five other people at a bus shelter in Tsuen Wan.

"With hindsight, earlier action should have been taken [last year], but with the rainy season more or less over it was considered more important to get things done by the next rainy season [this year]," Mr Pang said.

But even this target has been missed.

"The GEO has not issued any advice about bus stops on Hong Kong Island," Mr Pang said.

The department is also waiting to hear about bus stops in the New Territories and a large part of Kowloon.

Lantau Island, which has a high incidence of landslips, has been ignored.

In a letter to the *South China Morning Post*, the GEO's Government Geotechnical Engineer, John Shelton, said that following the Tsuen Wan tragedy, the GEO "promptly inspected many slopes next to bus stops and bus shelters in the Kwai Tsing and Tsuen Wan area".

Inspections were completed last October and recommended that 17 bus stops should be closed or moved.

The GEO then extended the study to cover the rest of Kowloon, the New Territories and Hong Kong Island using details supplied by Kowloon Motor Bus, China Motor Bus and Citybus.

The Lantao Bus Company was left out of the study although the Government has been unable to say why.

All three bus companies confirmed they supplied the information by the end of last year. But since then they have heard nothing.

Mr Shelton said the GEO was given the location of more than 1,000 bus shelters. About a quarter of shelters in the vicinity of slopes were heavily used.

"Inspections have already been carried out on many of these. The bulk of the remaining inspections will be completed in the near future and recommendations for closure or relocation made," he said.

But the GEO has been unable to explain why ... if it found high ris... it has not pas... formation to ... Department f... tion.

Mr Shelto... turn the *Post*'...

Mr Pang ... that two w... Wednesday's ... near a bus st... Peak Road, t... the Transport ... "was in no da... ment collapse".

The bus s... stone 11 was ... the GEO re... should be mo... following its K... Tsuen Wan ... Slopes near ... have also bee... the GEO, even... tially said th... should be clos...

"We did no... cel it because ... utilised. We ... GEO on Mar... them to confi... should be relo... ty grounds. Th... ed it and wrot... 29 saying 'it ... any signs of ... that basis we ... cate it," Mr P...

...ume of killer debris larger than forecast

...ragic errors ...vealed by ...i Wan sli...

Landslips rise to 91 as crucial recommendations yet to be co

Slopes still a big risk

By Renato Reyes

THE government has yet to complete a crucial reinstatement made by a Canadian expert to maintain slope safety.

Professor Norbert Morgenstern, who investigated the Kwun Lung Lau tragedy last year, recommended that drainage pipes running through slopes be checked regularly.

Drainage pipes underneath thousands of slopes have remained unchecked as the number of landslides in Hong Kong since the weekend rose to 91 yesterday.

A leaking drainage pipe was cited as one of the reasons for the collapse of the Kwun Lung Lau slope in July last year, in which five people were killed.

In his report, Prof Morgenstern said checking the drainage pipes was very important.

"The water pressure could build up higher in the ground and could contribute to a landslide," he said.

On Sunday teenager Chow Wai-keung was killed in a Clear Water landslide. Three others are believed to have been buried alive in another mudslip in Aberdeen.

Heavy rain has hampered emergency search teams of firemen in Aberdeen to rescue American Paul Souder, 46, his girlfriend Susan Ngai, 36, and a still unidentified woman.

"We could not continue digging in the rain," Fire Services Department divisional commander (Island West) Tong Kwok-yan said.

"There was water flowing down the slope and the loosened mud posed a threat."

Four excavators and 10 trucks were mobilised to remove the debris, which covered Nam Long Shan Road and blocked Hunan Wan Road.

The landslide demolished three factories in Po Chiang Wan and caused a serious fire at another.

Mr Tong said it would take at least 10 days to clear the debris, and the chance of finding survivors was slim.

Yesterday, an employee of the Chi Wo Metal Factory, Tam Chung-chi, who was staying in premises with two other workers, relived the horror of the avalanche.

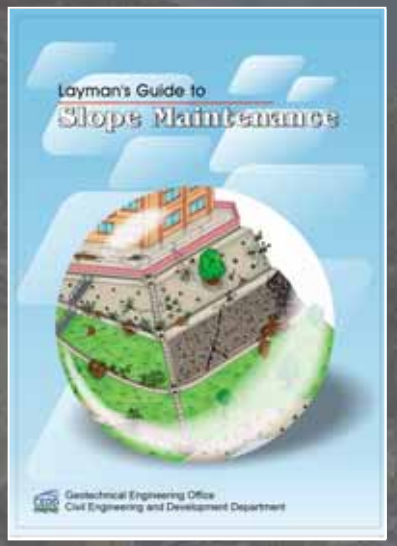
"I was sleeping and suddenly, I heard a huge noise. I was pushed away by the mud before I could wake up. I was trapped between some wooden boards. Luckily, two of my workmates, who managed to escape, found me and rescued me," 45-year-old Mr Tam said.

He suffered minor head and hand injuries and was discharged after treatment at Queen Mary Hospital.

- Underlying reasons
- Reduced awareness of potential landslide risk after many uneventful years
- Increased expectation
- Aversion to multiple-fatality
- Geotechnical process not 100% robust *(technological limitations and human errors)*

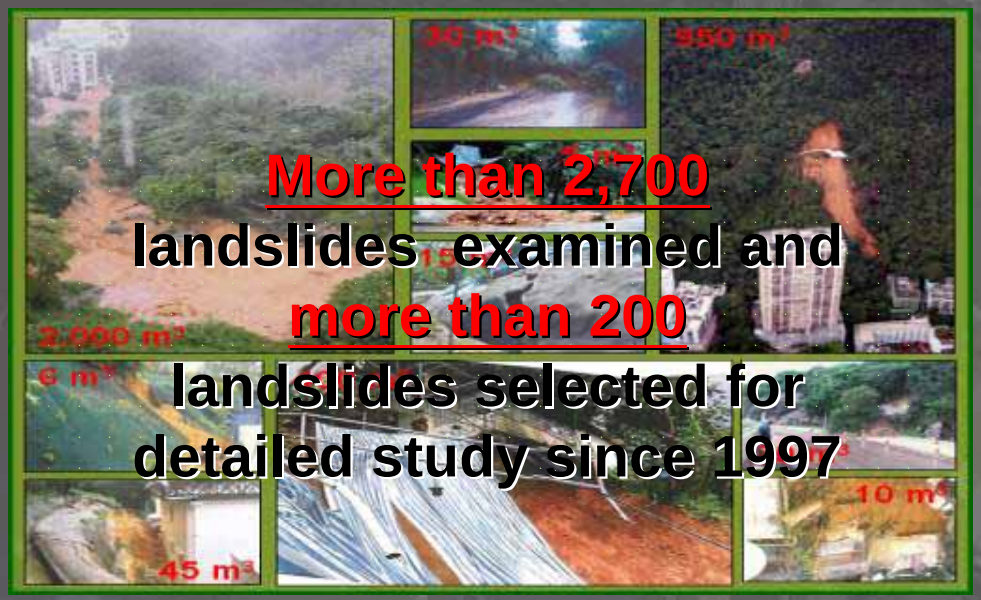
Enhancement of Slope Safety System

Risk assessment and management



Slope maintenance

Landslip warning system



Systematic landslide investigation

Public education

Roving Exhibition

Public Advisory Services

School Talk

Slope Safety Seminar

Systematic Landslide Investigation

200 - 800 landslides reported per year

All landslides

(1) Examination

~10%

(2) Landslide study/review

~1%

(3) Forensic study

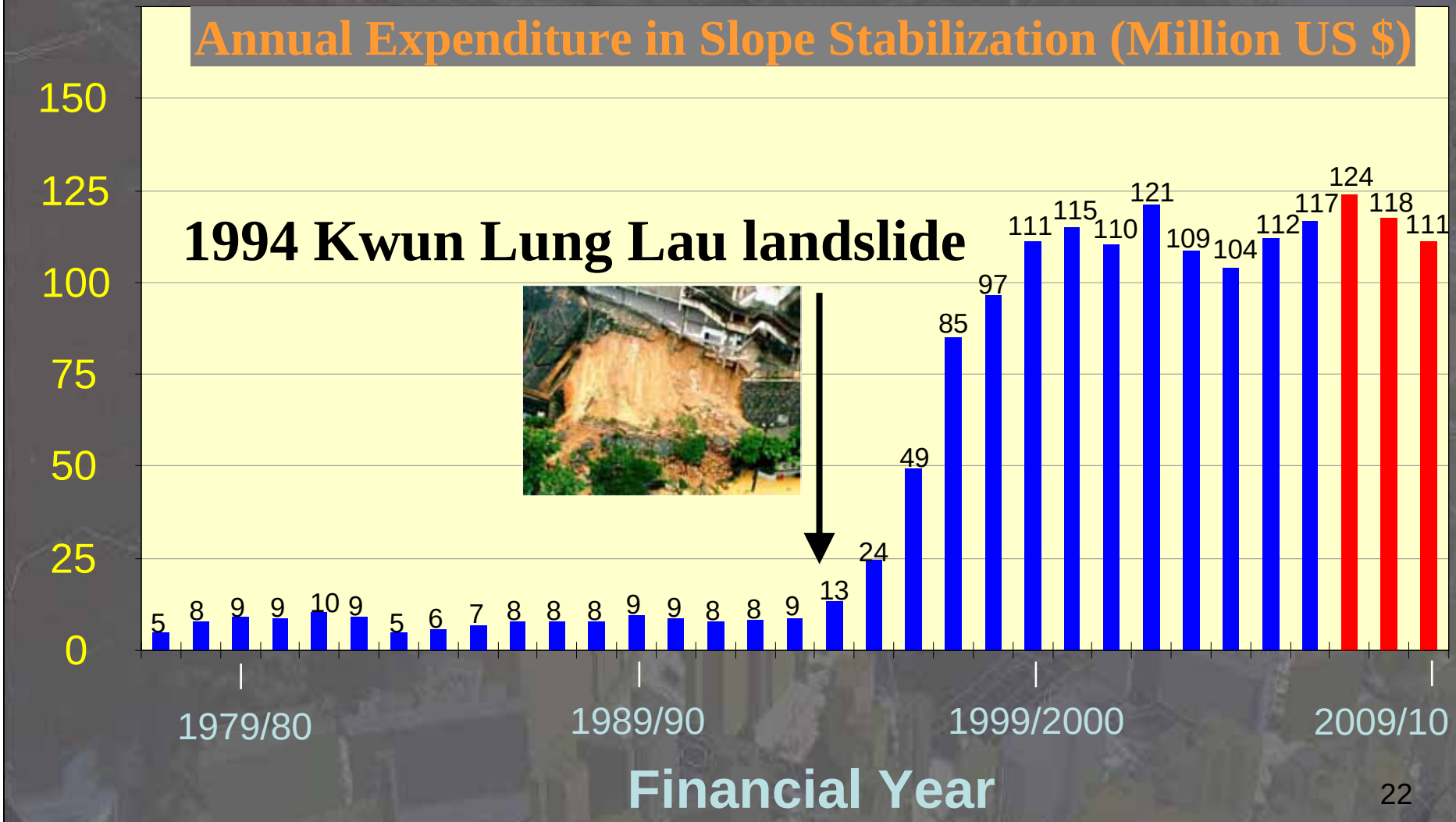
Aims：

1. Improve understanding of slope behaviour
2. Enhance slope engineering practice
3. Audit slope safety system

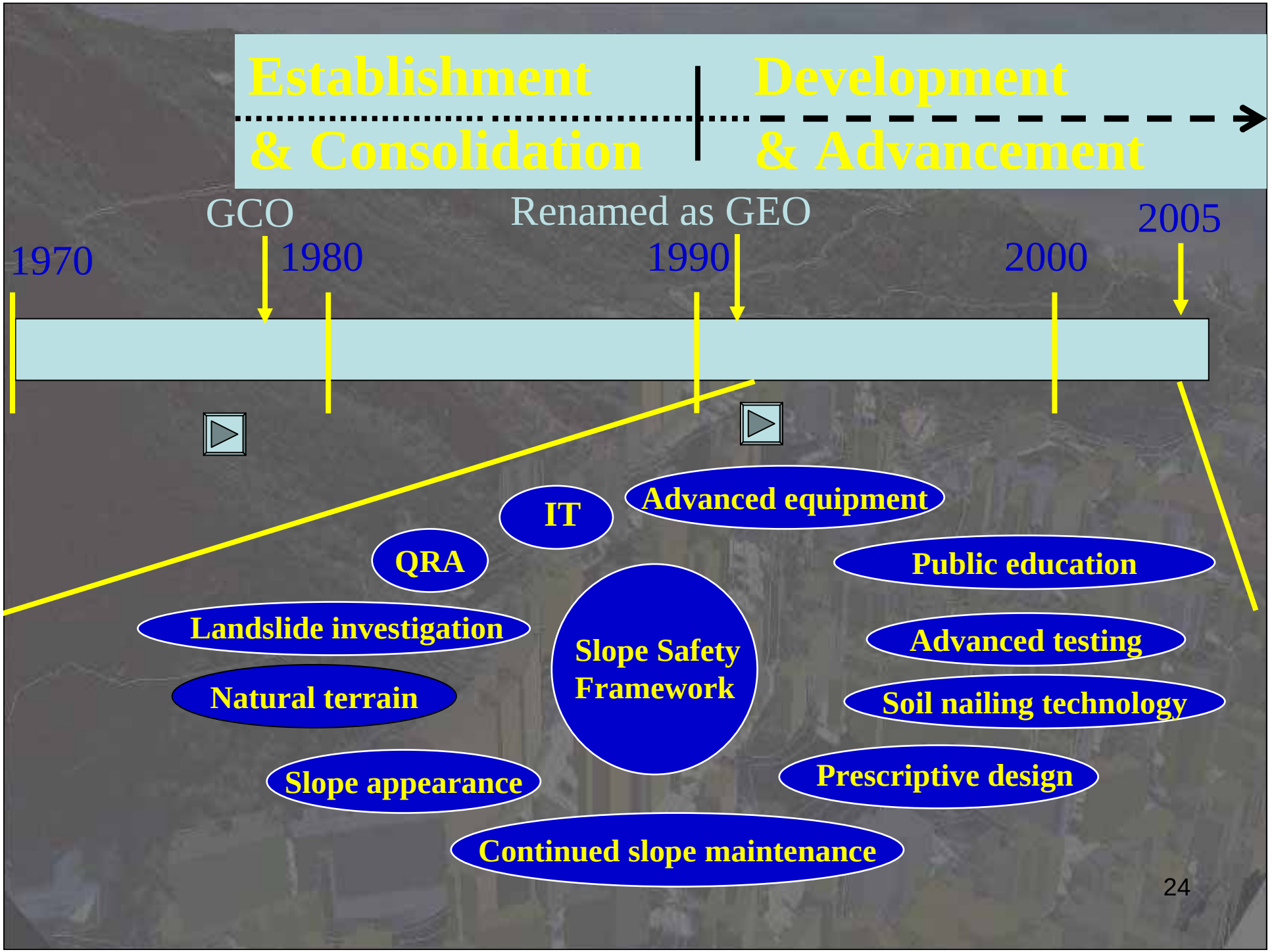
+ external review by Slope Safety Technical Review Board

US$ 4 Million per year

Acceleration of Landslip Preventive Measures Programme (LPMP)



Enhancement of Slope Appearance


Establishment & Consolidation
Development & Advancement
GCO
Renamed as GEO
1970
1980
1990
2000
2005
IT
Advanced equipment
QRA
Public education
Landslide investigation
Slope Safety Framework
Advanced testing
Natural terrain
Soil nailing technology
Slope appearance
Prescriptive design
Continued slope maintenance

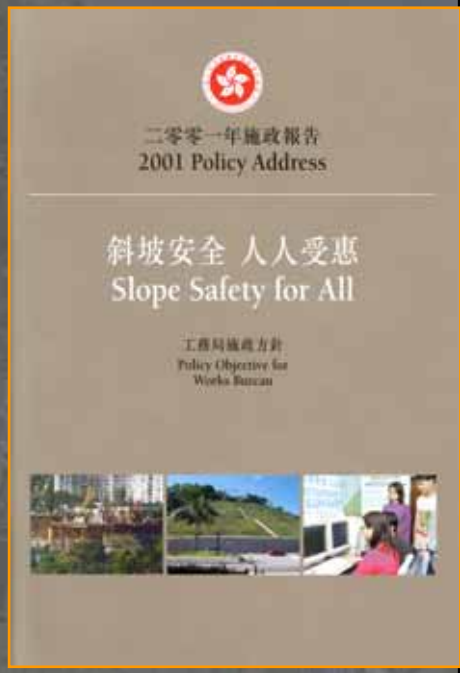
Hong Kong
Slope Safety System

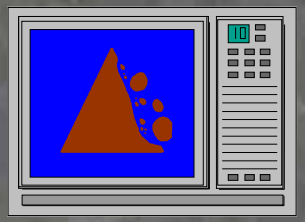
- System improvement through the formation of a comprehensive framework of the Slope Safety System by the HKSAR Government. – Seven key results areas
- Key tasks undertaken in the Slope Safety System are described

Hong Kong
Slope Safety System

- Seven Key Result Areas

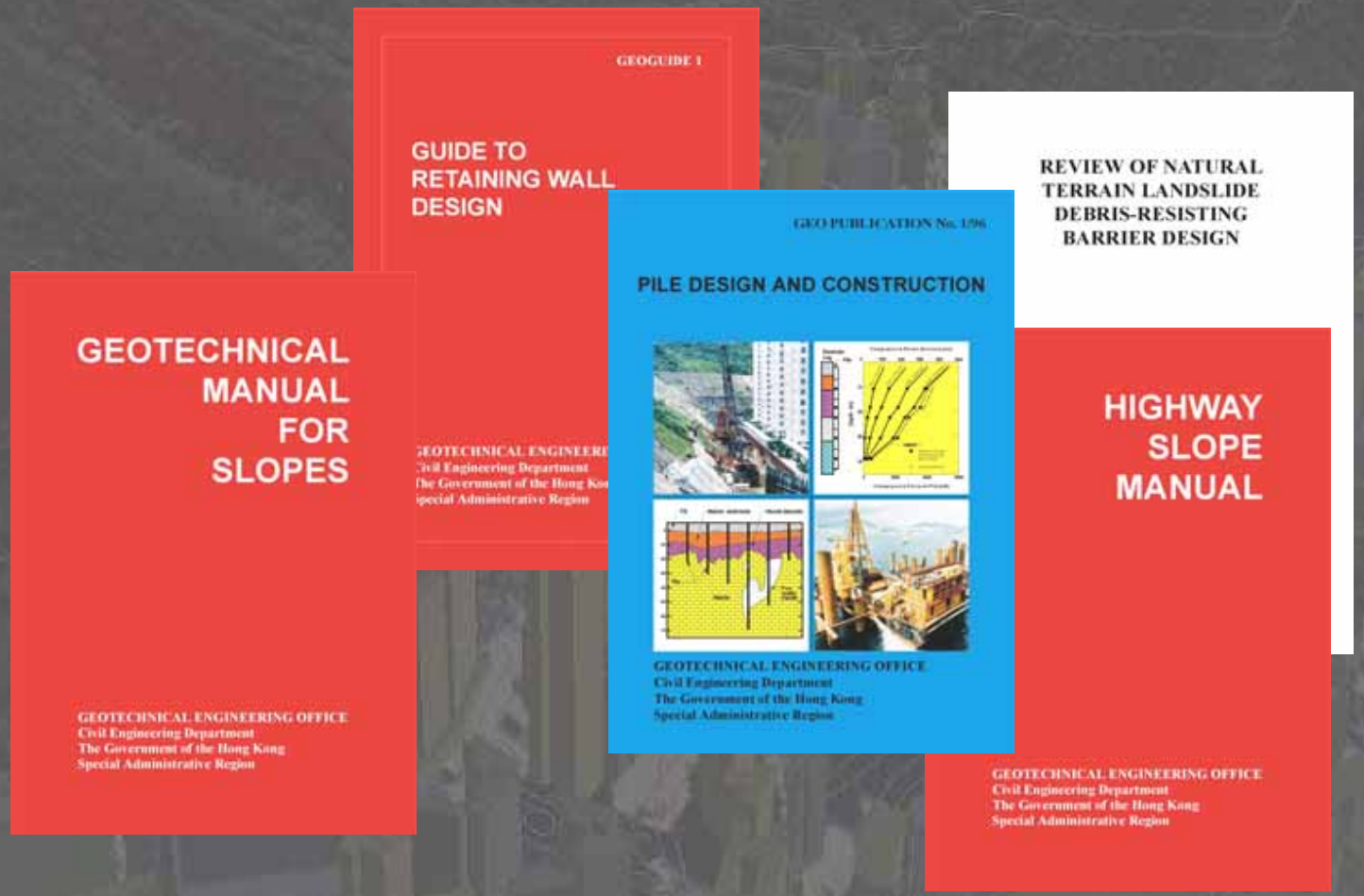
1. Improve slope safety standards, technology, and administrative and regulatory frameworks
2. Ensure safety standards of new slopes
3. Rectify substandard government slopes
4. Maintain all government man-made slopes
5. Ensure that owners take responsibility for slope safety
6. Promote public awareness and response in slope safety through public education, publicity, information services and public warning
7. Enhance the appearance and aesthetics of engineered slopes





Ensure that New Slopes Meet Safety Standards

- Improve slope safety standards, administrative and regulatory frameworks



Ensure that New Slopes Meet Safety Standards

- Improve slope safety standards, administrative and regulatory frameworks

Ensure that New Slopes Meet Safety Standards

❖ Improve slope safety standards, administrative and regulatory frameworks

- Systematic investigation of landslides has brought improved understanding of the mechanism of landsliding.
- Areas for improvement identified as feedback to enhance the elements in the Slope Safety System.

Goals of Systematic Landslide Investigations

Safety-net :
identify slopes requiring action

Technical development : enhance slope engineering practice

System review : identify areas for improvement

Forensic investigation

Ensure that New Slopes Meet Safety Standards

❖ Through systematic landslide investigations, we have:

- Improved reliability of engineered slopes.
- Improved slope safety risk management system.
- Enhanced public safety

Further Enhancement of Geotechnical Control by Setting-up the Registered Geotechnical Engineers (RGE) in 2005

Enhancement of Geotechnical Control

- The Buildings (Amendment) Ordinance 2004 establishes a register of geotechnical engineers and introduces the requirement for the appointment of a RGE for the geotechnical elements of building works
- The registration system has commenced operation since 31.12.2004
- With effect from 31.12.2005, a RGE is required to be appointed for the geotechnical elements of building works

Enhancement of Geotechnical Control

- The duties and functions of a RGE are classified into “executive role” and “advisory role”

Executive tasks:

- Prepare and sign the prescribed geotechnical plans and reports
- Certify that the works have been carried out in accordance with the approved plans, and that the works completed are geotechnically safe

Advisory tasks:

Prepare and sign the geotechnical report/supporting documentation

Enhancement of Geotechnical Control

Executive Role – Geotechnical Tasks
Ground Investigation in Scheduled Areas
Ground Investigation in Non-scheduled Areas
Site Formation
Groundwater Drainage Works in Scheduled Area 1
Water Supply and Wells
Remedial Works to Dangerous Hillsides
Long Term Monitoring (Post Occupation Permit)

Enhancement of Geotechnical Control

Advisory Role – Geotechnical Tasks
Demolition Affecting Slopes and Retaining Walls
Geotechnical Assessment for General Building Plan where required
Foundation in Scheduled Areas Nos. 1, 2 & 4 and Designated Area of Northshore Lantau
Foundation Affecting Slope and Retaining Wall
Excavation and Lateral Support
Superstructure (Report on geotechnical design parameters)

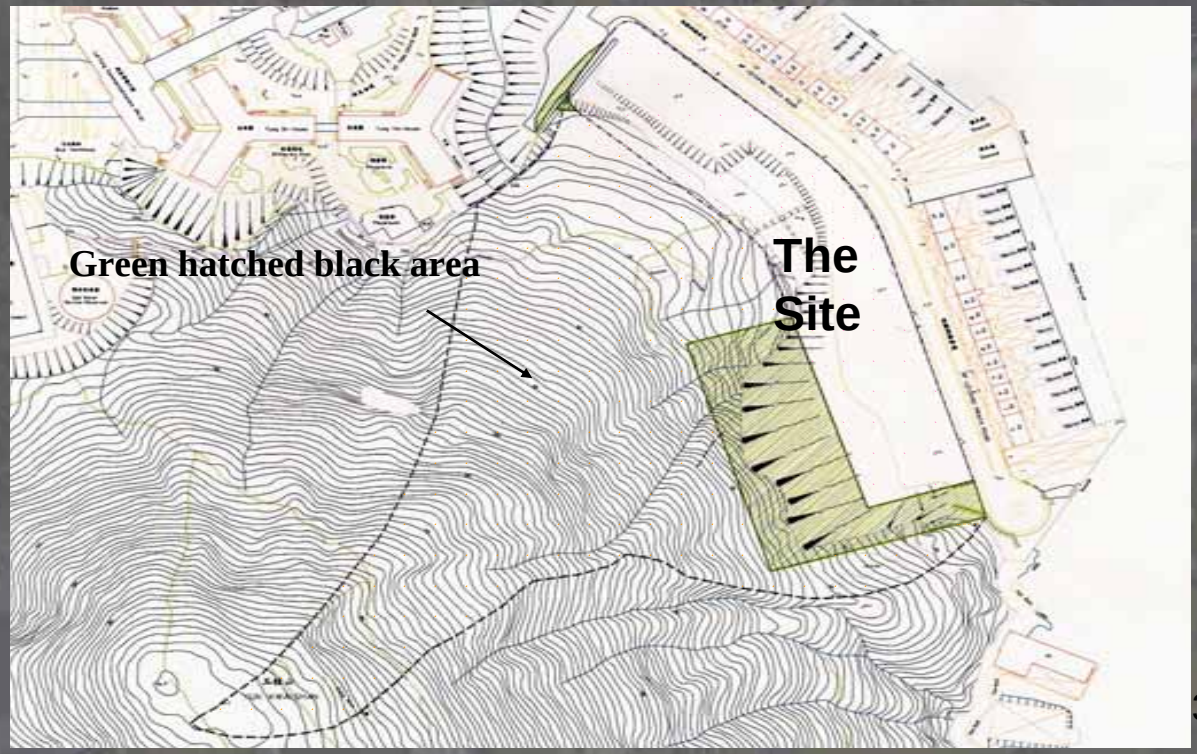
Ensure that New Slopes Meet Safety Standards

❖ Checking new slopes

- **Dedicated team of geotechnical engineers**
- **Audit of designs of new geotechnical works (private and public)**
- **Audit of standard of site supervisions of geotechnical works (private and public)**

Ensure that New Slopes Meet Safety Standards

- Enhancing land use planning
  - **Providing geotechnical advice on new developments to ensure that slope safety is duly considered at the early planning stage**

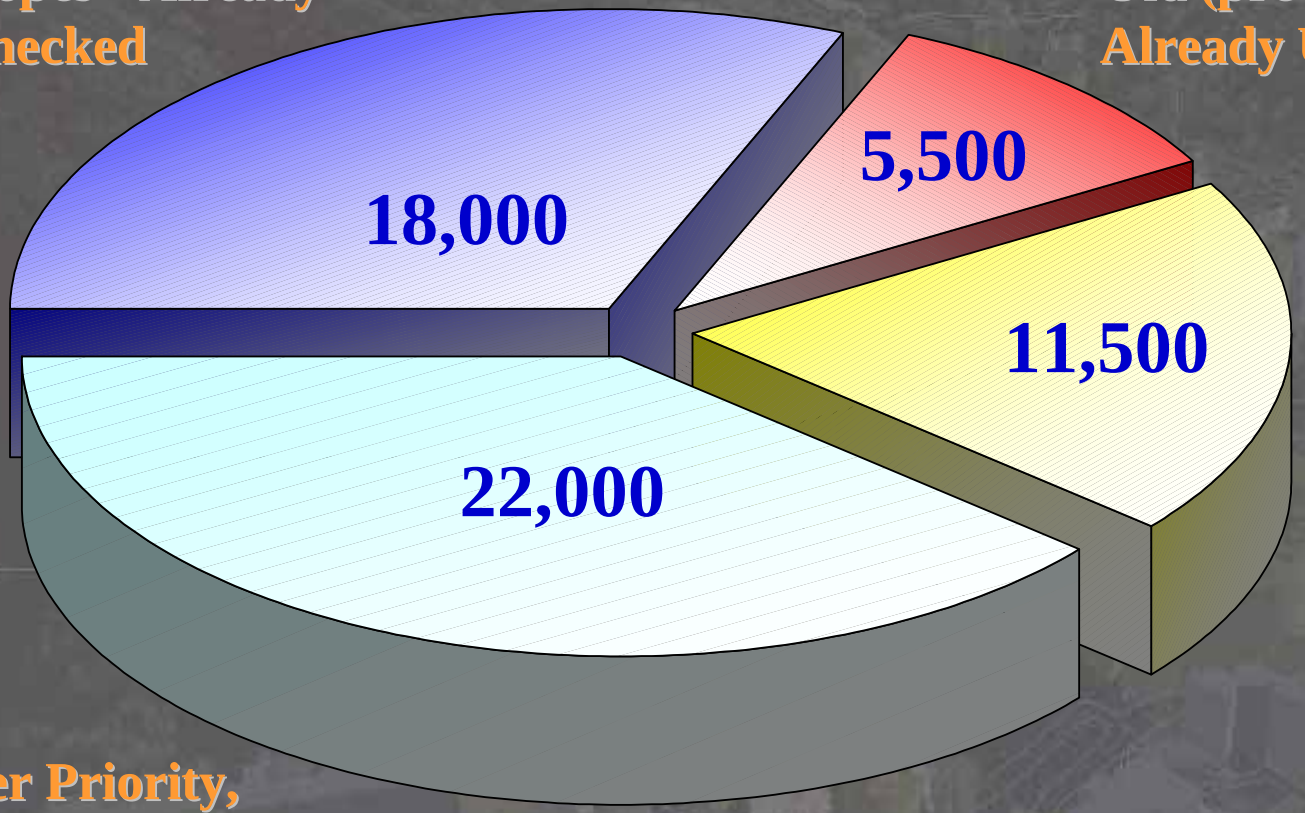


Ensure that New Slopes Meet Safety Standards

- Enhancing land use planning
  - **Where it is difficult to develop due to geotechnical limitations, we may recommend a change in the land use.**

Enhance the Stability of Old Man-made Slopes

Distribution of Man-made Slopes in the Slope Catalogue



Enhance the Stability of Old Man-made Slopes

❖ Upgrading of old government man-made slopes

- 57,000 registered man-made slopes (39,000 Government and 18,000 private)
- **For the old government man-made slopes,**
  - Implemented the 5-year Accelerated Landslip Preventive Measures (LPM) Project (1995-2000)
  - Implementing the 10-year Extended LPM Project (2000 - 2010)

Before LPM

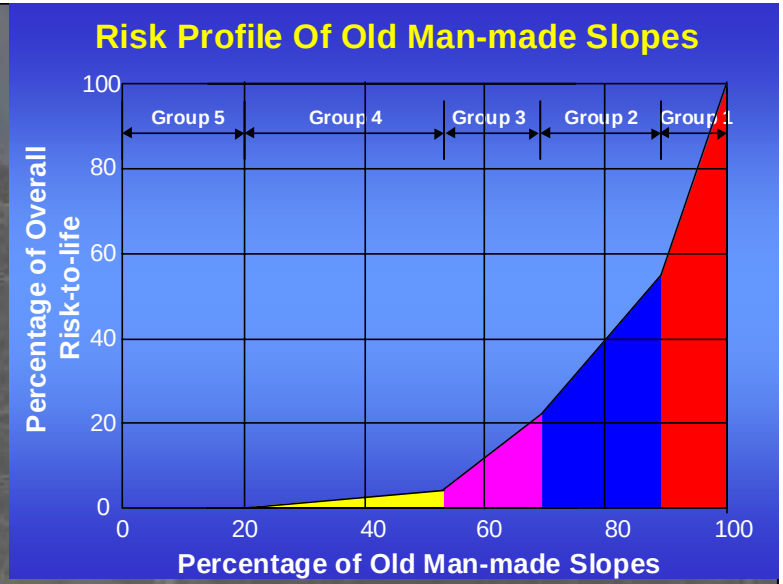
After LPM

Enhance the Stability of Old Man-made Slopes

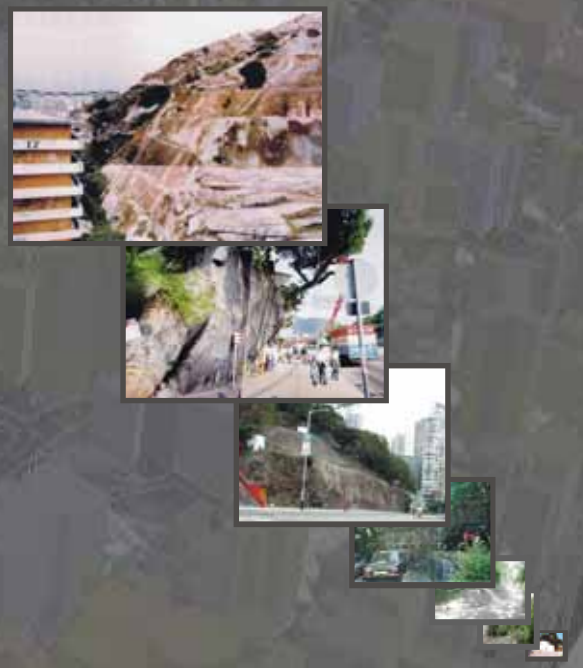
- Upgrading of old private man-made slopes
  - **Safety screening of private slopes and issue Dangerous Hillside Orders where needed**
  - **Proactive advisory service to private owners**

Risk from Old Slopes

About half of the risk derives from 10% of the slope population

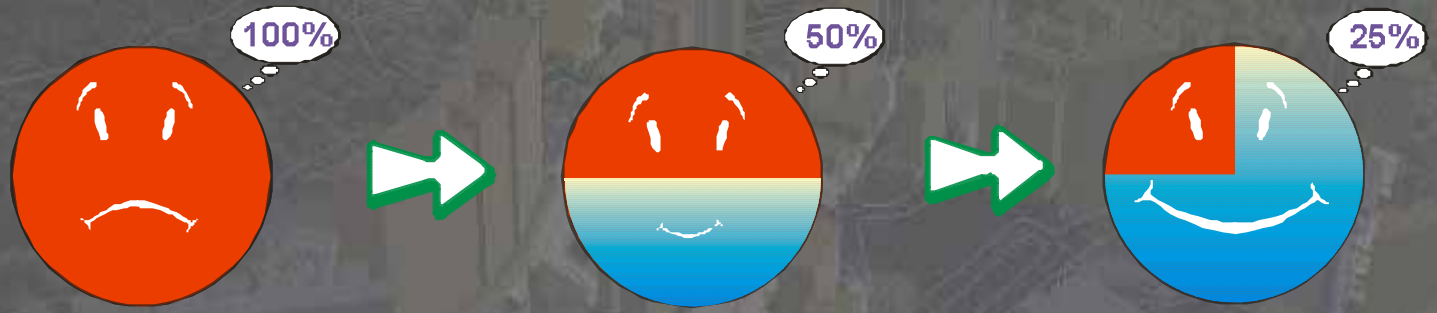


- **Upgrading a small proportion of old slopes would result in a major risk reduction**
- **Point to the importance of a risk-based ranking system for prioritising landslide preventive actions**
- **Formulate risk reduction target (by 2010, half the risk in 2000)**



TARGETS OF REDUCING LANDSLIDE RISK FROM OLD MAN-MADE SLOPES

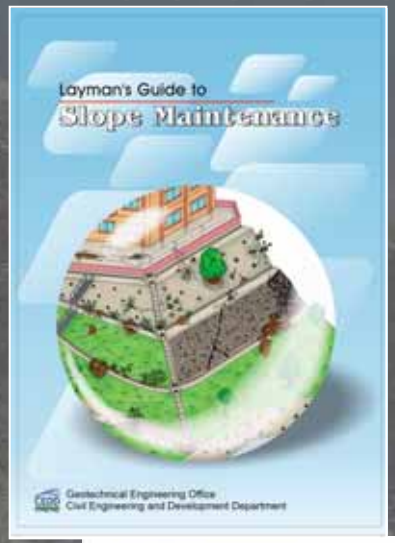
Landslide Risk

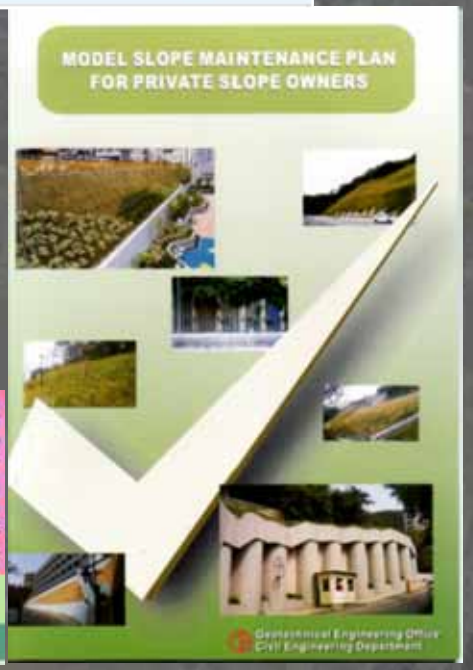


Enhance the Stability of Old Man-made Slopes

- ❖ Promote slope maintenance

- Encourage private owners to maintain their slopes
  - **Model Slope Maintenance Plan and training video**
  - **Layman's Guide to Slope Maintenance**
  - **Leaflets on slope maintenance**



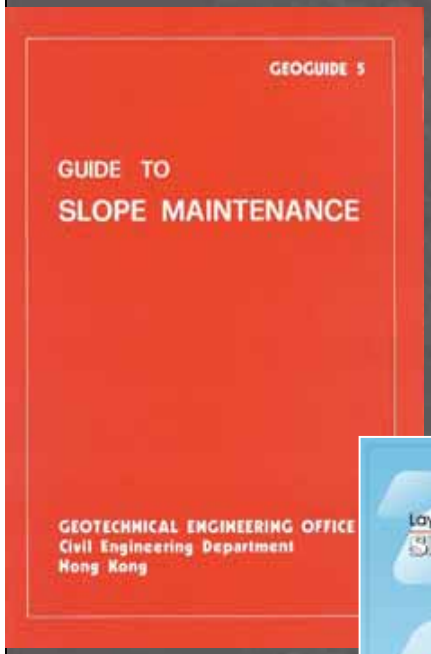


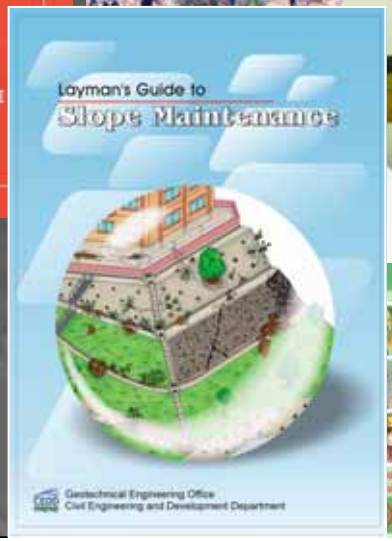
Enhance the Stability of Old Man-made Slopes

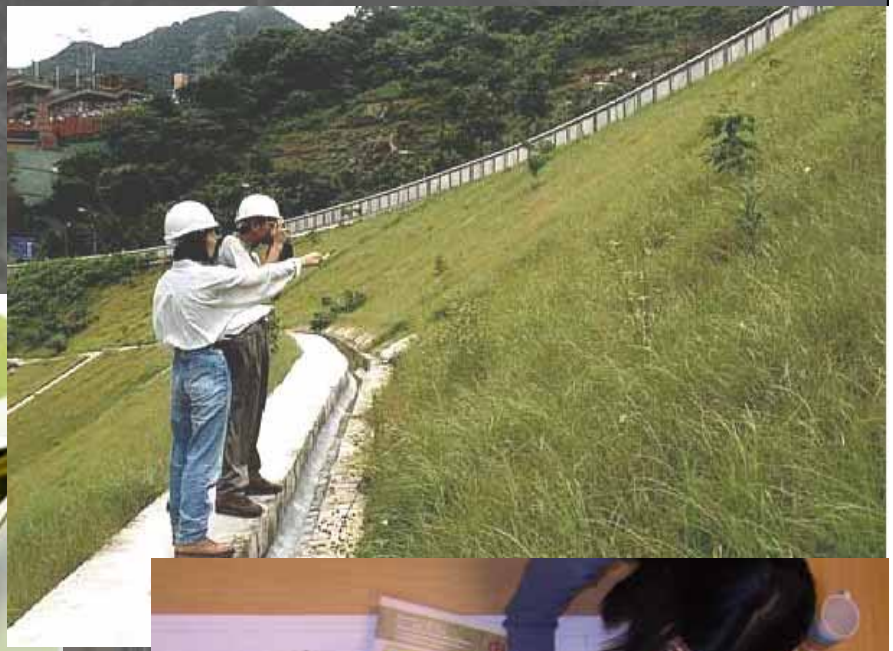
- Promote slope maintenance

Enhance the Stability of Old Man-made Slopes

- Promote slope maintenance





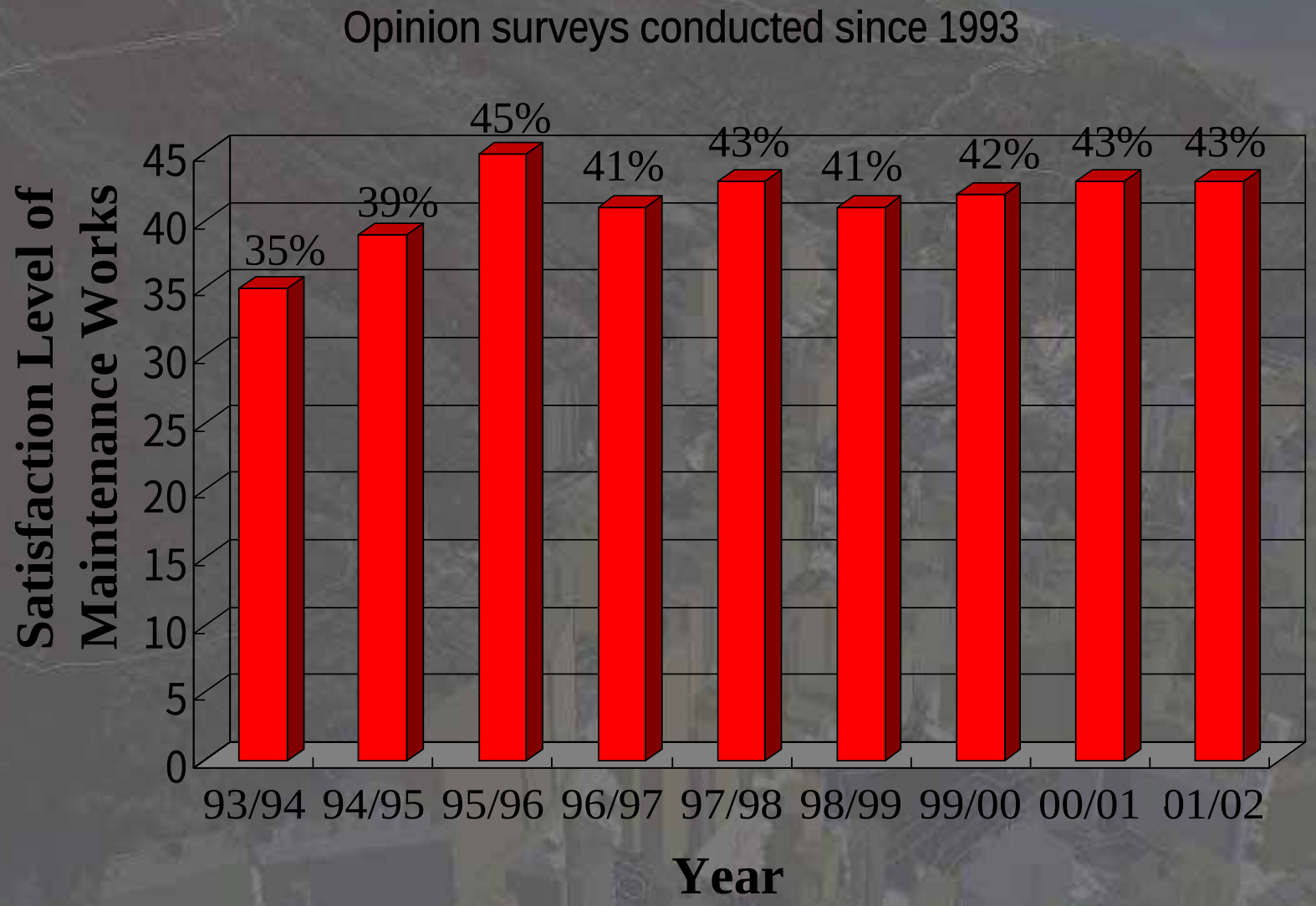


Enhance the Stability of Old Man-made Slopes

❖Promote slope maintenance

- Encourage private owners to maintain their slopes
  - **Seminars**
  - **Internet training course**

Slope Maintenance Works by Private Owners



Enhance the Stability of Old Man-made Slopes

❖ Providing information services

- **Provide comprehensive slope information for free public access on the Internet (http://hkss.cedd.gov.hk)**

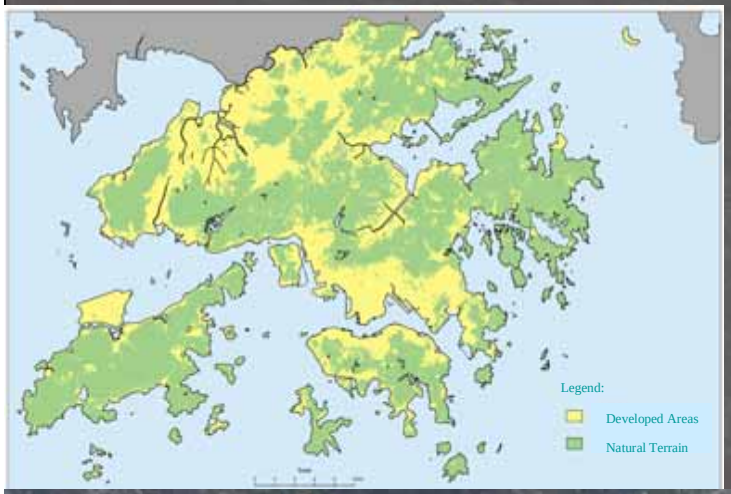
Enhance the Stability of Old Man-made Slopes

❖ Providing information services

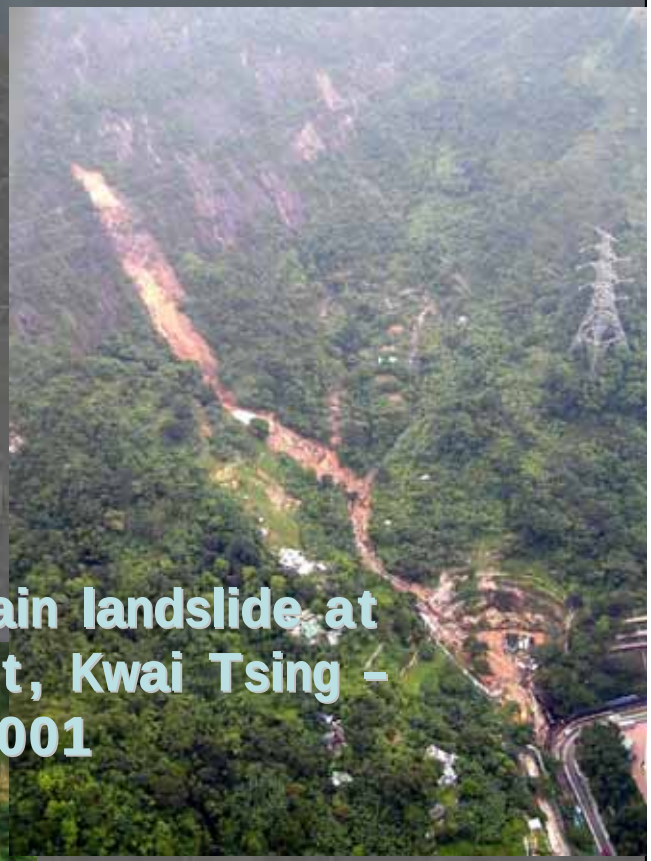
- **Provide information on slope maintenance responsibility by Lands Department from their Systematic Identification of Maintenance Responsibility of Slopes (SMRIS) on the Internet (http://www.slope.landsd.gov.hk/smris/)**


Natural Terrain
Landslide Risk
Management

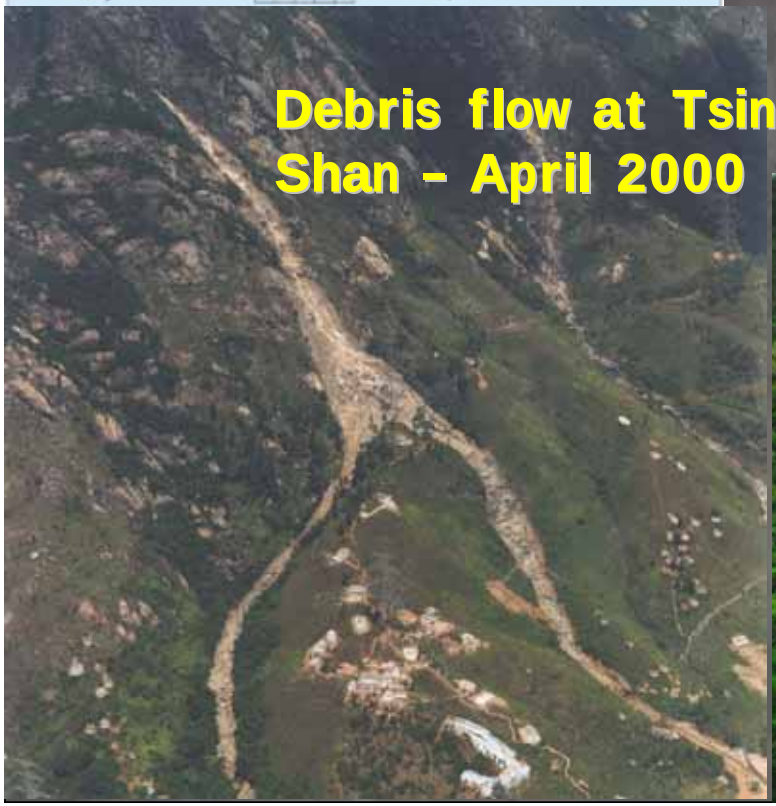
Mitigate Natural Terrain Landslide Risk



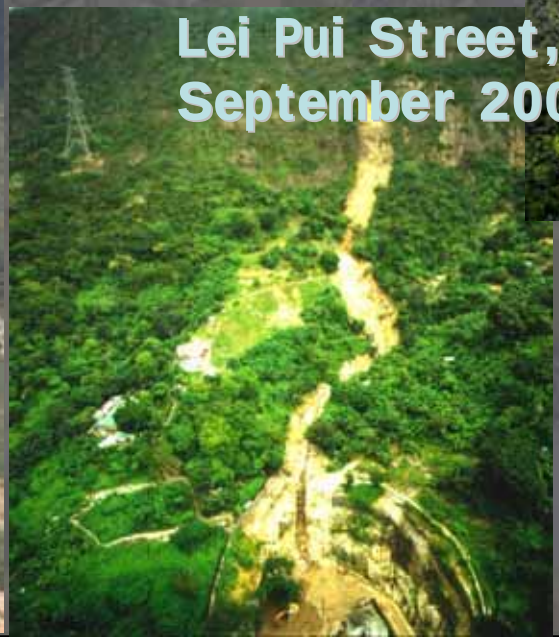
>60% area - Natural terrain



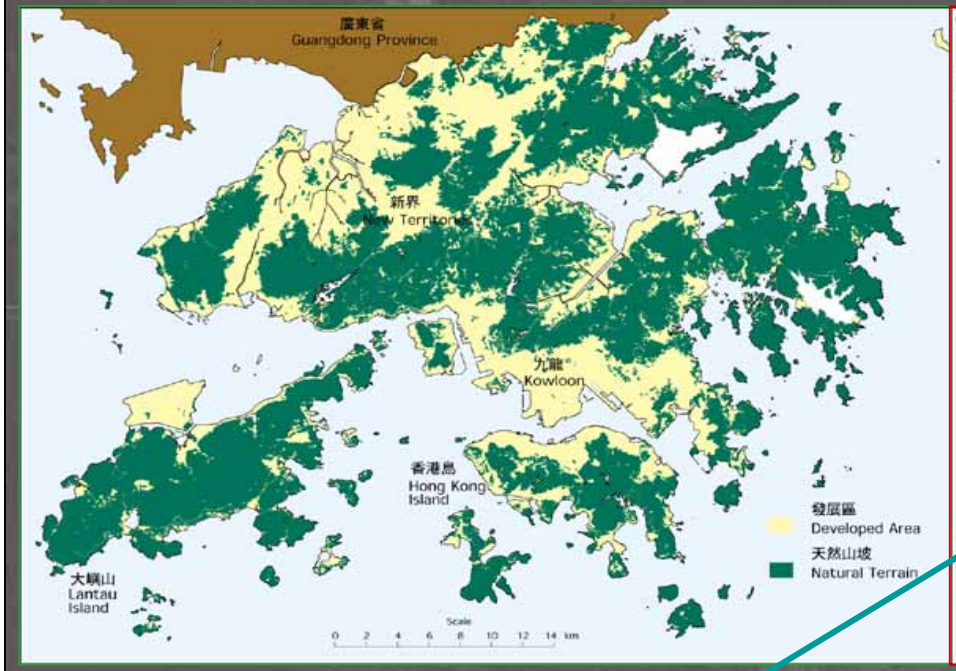
Natural terrain landslide at Lei Pui Street, Kwai Tsing – September 2001



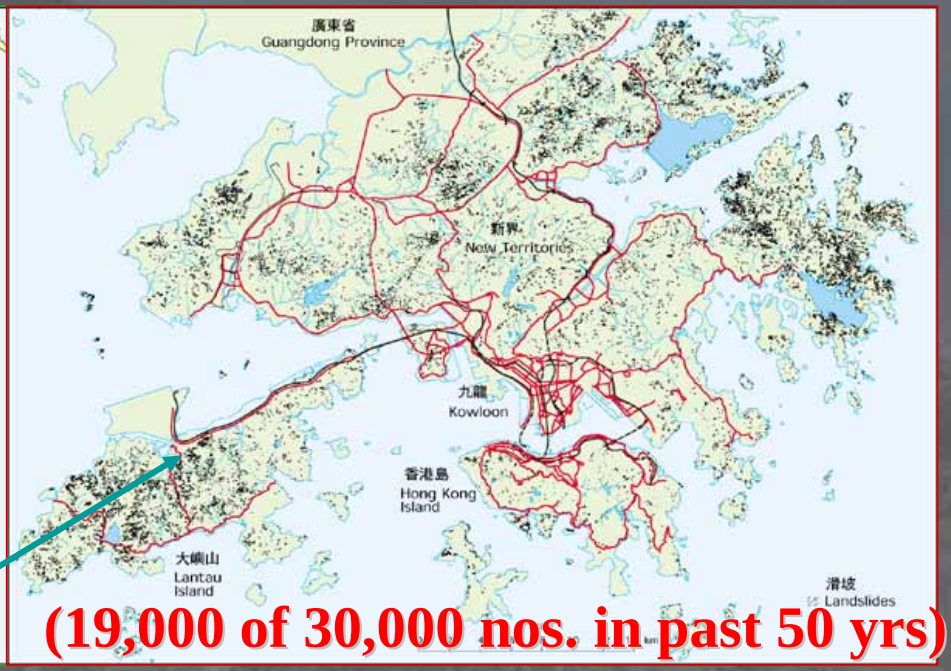
Debris flow at Tsing Shan – April 2000



Natural Hillside

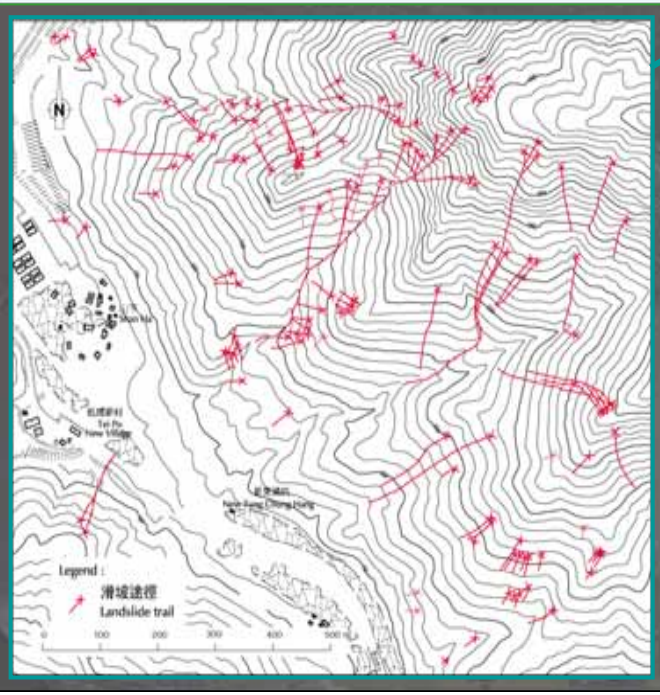


Natural Terrain Landslide Inventory



(19,000 of 30,000 nos. in past 50 yrs)

Natural Terrain Landslides



Recent Advances in Natural Terrain Risk Management

- Enhanced understanding of failure mechanisms
- Rationalisation of natural terrain risk management strategy
- Development of new tools for natural terrain hazard studies
- Availability of practical solution for risk mitigation

Risk Management Strategy

	New development (control risk increase)	Existing development (reduce risk; fix it before too late)
Man-made slopes (1970's)	Design and check new slopes	Retro-fitting (e.g. LPM)
Natural hillside (2000's)	NTHS for new development	React to 'known' hazards

NTHS = natural terrain hazard study


Many landslides
in a heavy rainstorm
Small failure can be
serious in Hong Kong
Manage Natural Terrain Landslide Risk
Developing closer
to natural hillside
Low-frequency
large-magnitude event

Current Practice in Managing Natural Terrain Risk to As Low As Practically Achievable

Existing development

… 'react-to-known-hazard'

New development

… contain overall risk increase

Continuing development of practice from experience gained and technical advances

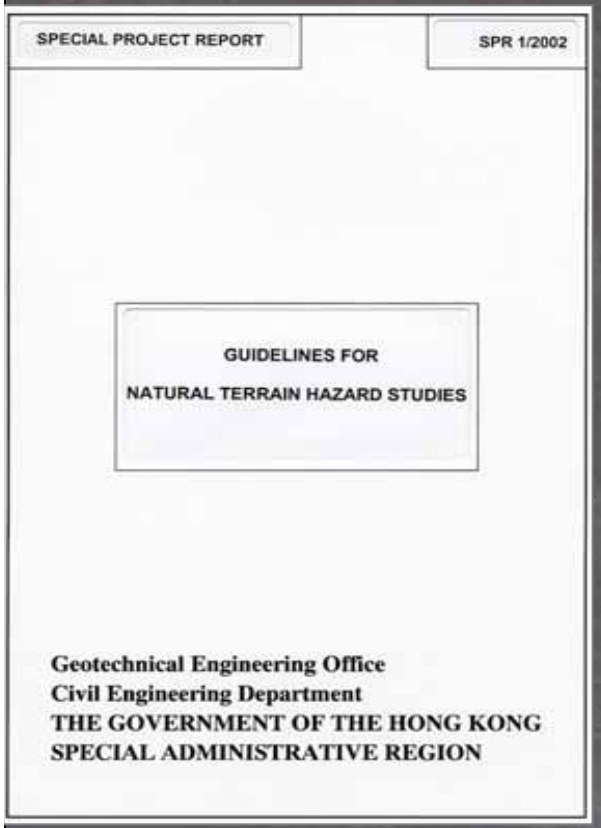
Approaches of NTHS (SPR 5/2000)

Approach	Design Concept	Guidance
Factor of Safety (FOS)	Study stability of hillside and design any slope stabilization measures to meet the required FOS (prevent failure)	Geotechnical Manual for Slopes
Quantitative Risk Assess-ment (QRA)	Assess risk to development site and determine any risk mitigation measures based on risk guidelines (control risk)	GEO Report No. 75
Design Event Approach (DEA)	Study landslide hazards and determine the design event and any mitigation measures (control risk)	SPR 1/2002 NTHS guidelines


Screening for New Developments
(Planning and Land Disposal Stage)
'In-principle objection'
to new development
subject to severe hazard
35°
'Alert'
Natural Terrain
Hazard Study
required for new
development that
may be affected
by NT hazard
20°
* with case-by-case
consideration/judgement
and ≤ 50 m from
ground ≤ 15° steep

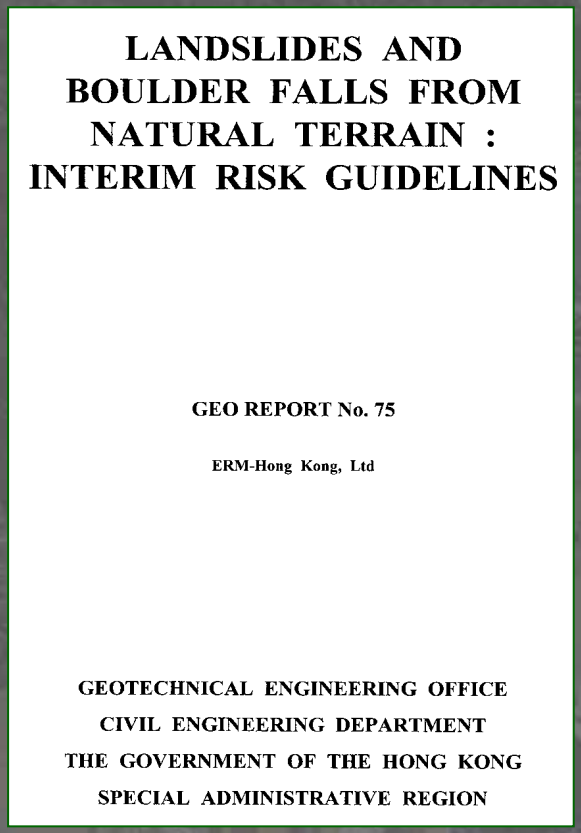
Technical Guidelines & Professional Practice

Natural Terrain Hazard Study



SPR 1/2002
(GEO Rpt No. 138)

Risk Guidelines



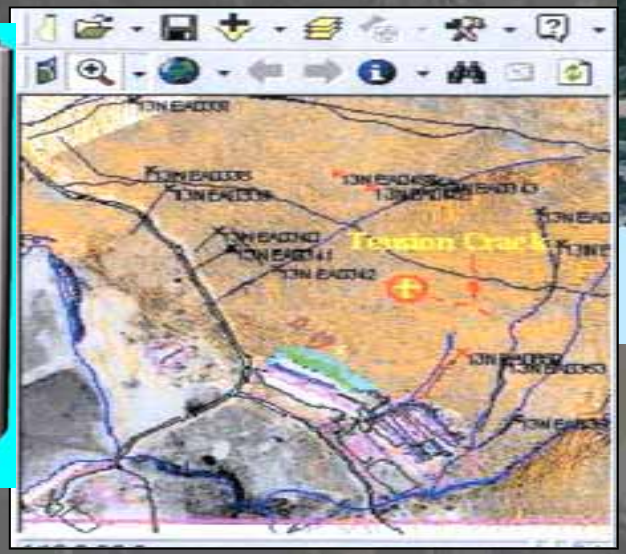
GEO Rpt No. 75

Design of Debris Barriers

GEO Rpt No. 104


Check dam
Protective barriers
Practical solutions for hazard mitigation
Boulder fence
危 險
前面山坭傾瀉，不得內進
DANGER
LANDSLIDE AHEAD
NO ENTRY
此路封閉
THE PATH IS CLOSED
Important facility away from vulnerable area

Advances in Digital Technologies Open up Opportunities in Systematic Management of Natural Terrain Landslide Hazards



Minimise Damage Caused by Landslides

❖Improving the safety of squatters

- Clear squatters on slope safety grounds
  - **some 75,000 squatters cleared and rehoused**

Landslides Affecting Squatters

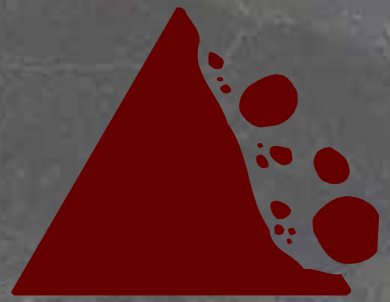
Before Clearance

After Clearance

Landslides Affecting Squatters at Lei Yue Mun Village

Minimise Damage Caused by Landslides

- **Issue Landslip Warnings in times of heavy rain and post warning signs**



- **Provide Landslide Emergency Service**

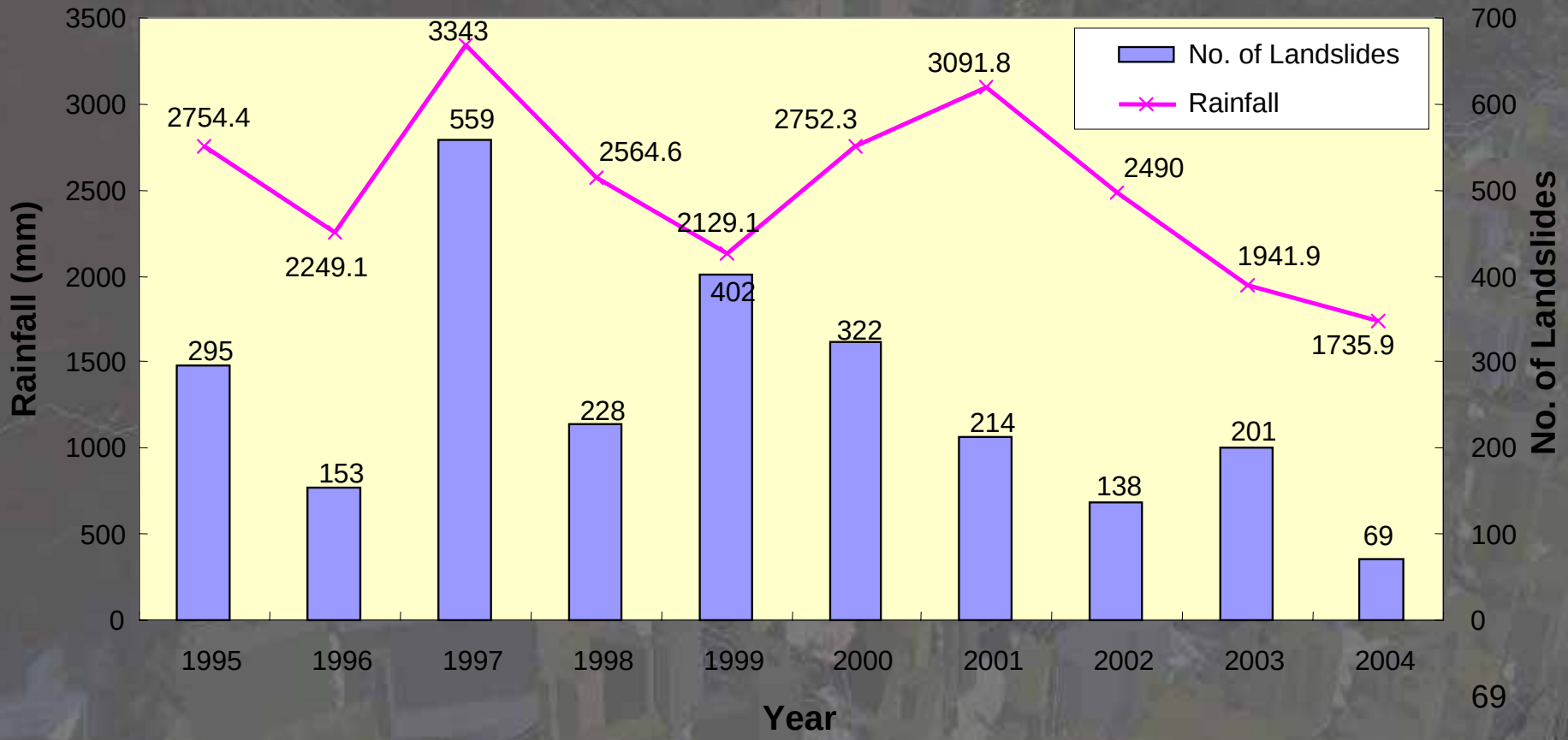
Automatic Raingauges

Locations of 110 Nos. of Raingauges

Automatic Raingauges

Communication of Severity of Rainstorms

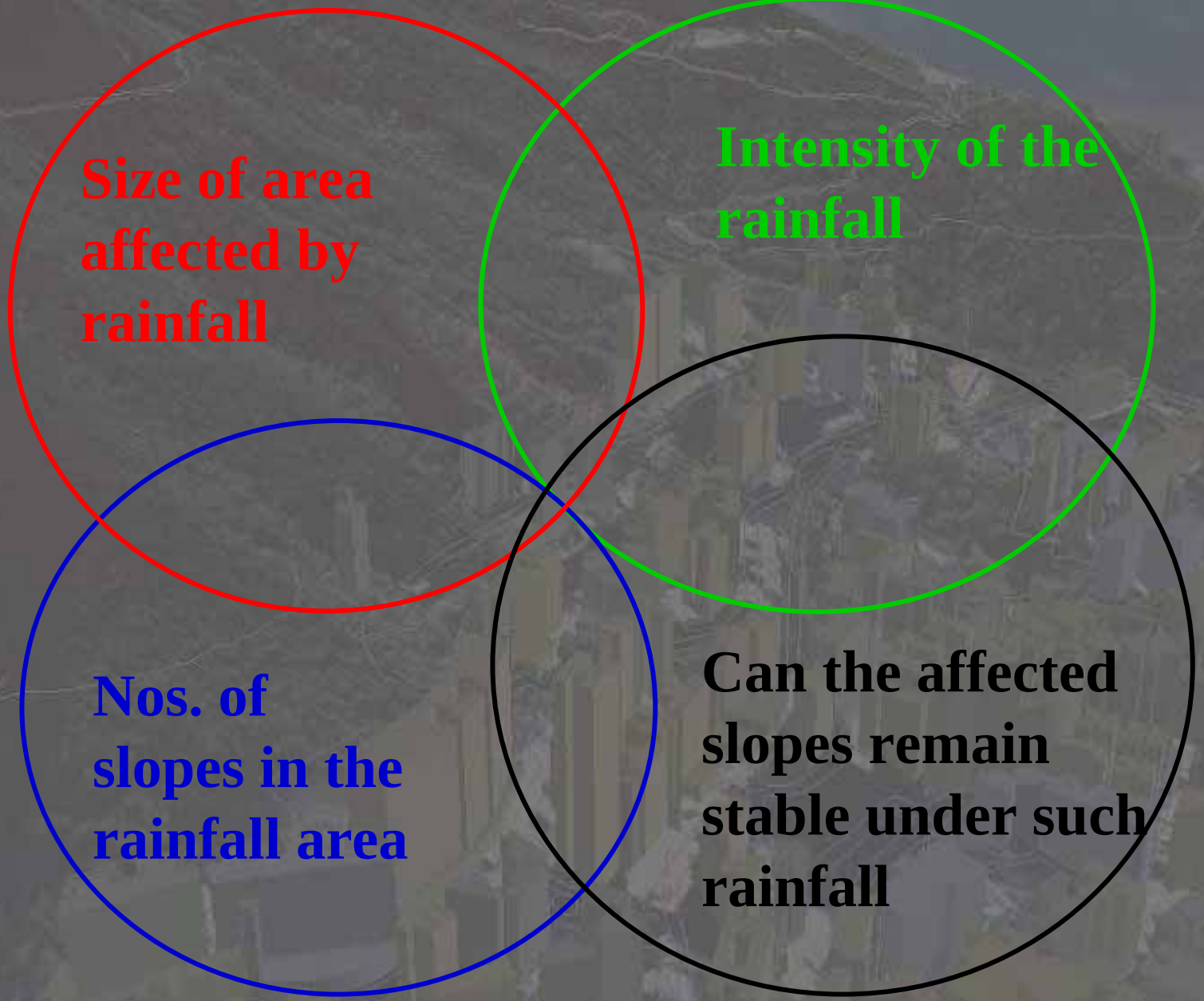
Annual rainfall does not reflect the true picture of landslide potential - Misleading message to the public !



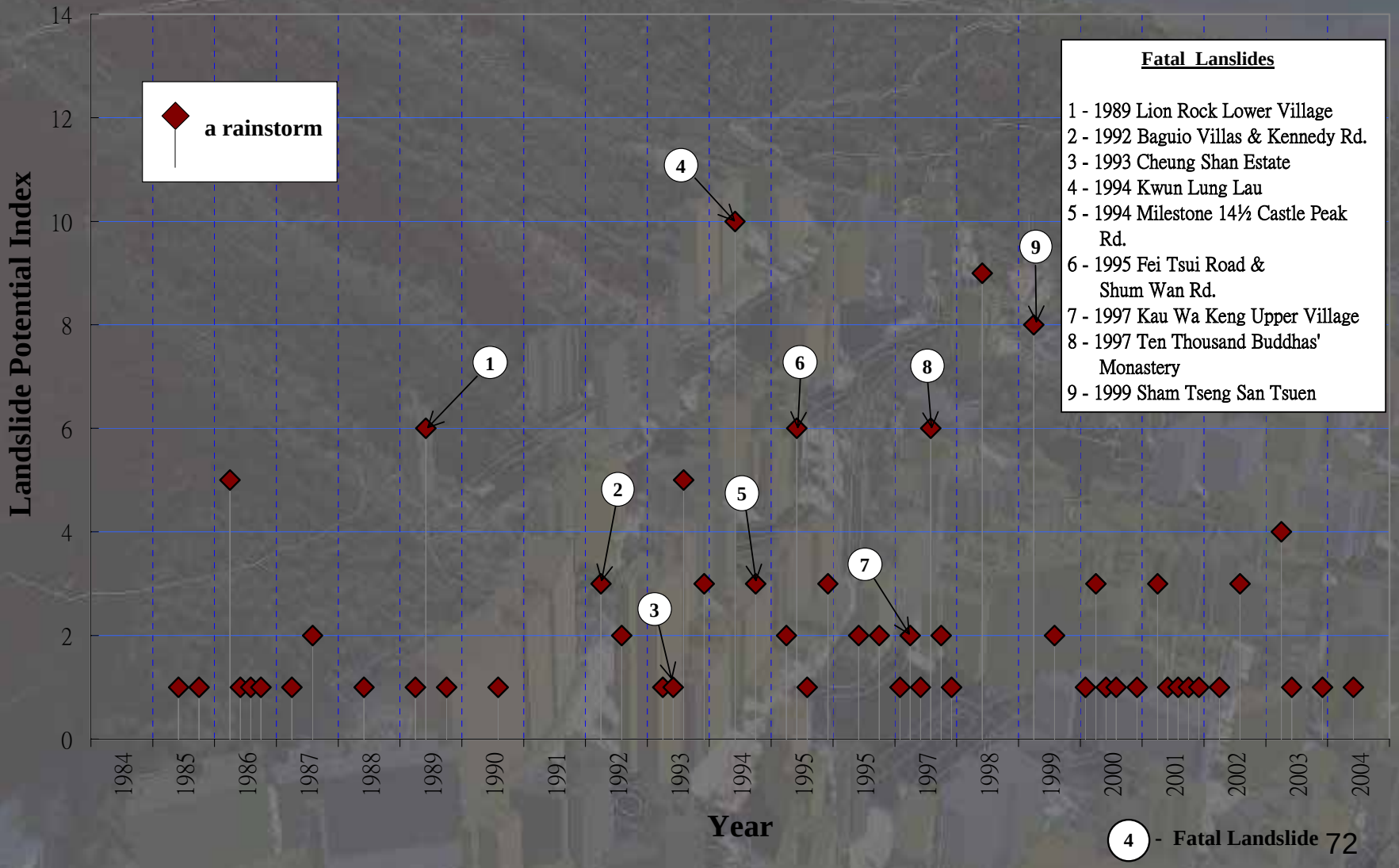
Communication of Severity of Rainstorms

Landslide Potential Index (LPI) may help us to communicate with the public about the severity of a rainstorm in terms of its potential to cause landslides.

Landslide Potential is a Function of 4 Factors



Communication of Severity of Rainstorms – Landslide Potential Index

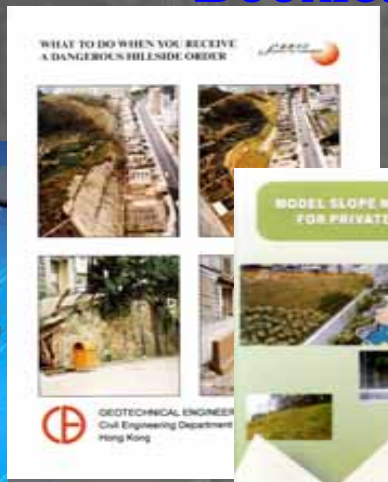


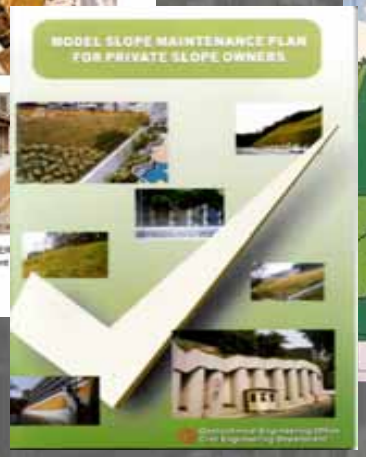
Launch Public Education & Publicity on Slope Safety

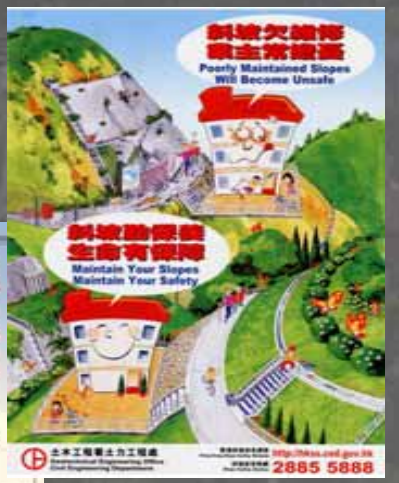
- **To remind slope owners their responsibility of slope maintenance**
- **To educate the public on proper precautionary measures during heavy rain or when the landslip warning is in force**

Booklets

Leaflets



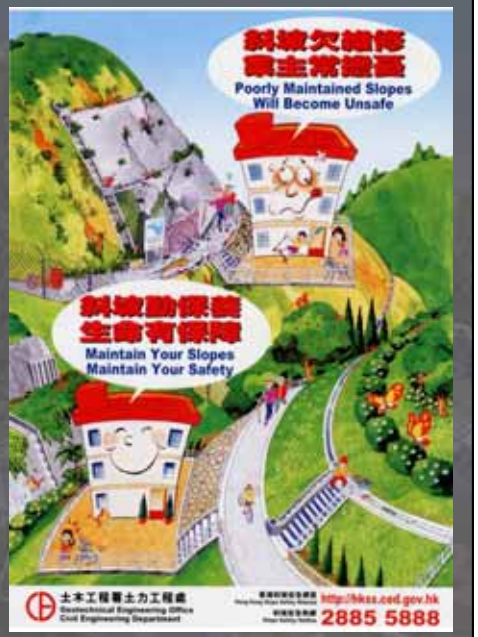




Posters

VCDs

Launch Public Education & Publicity on Slope Safety



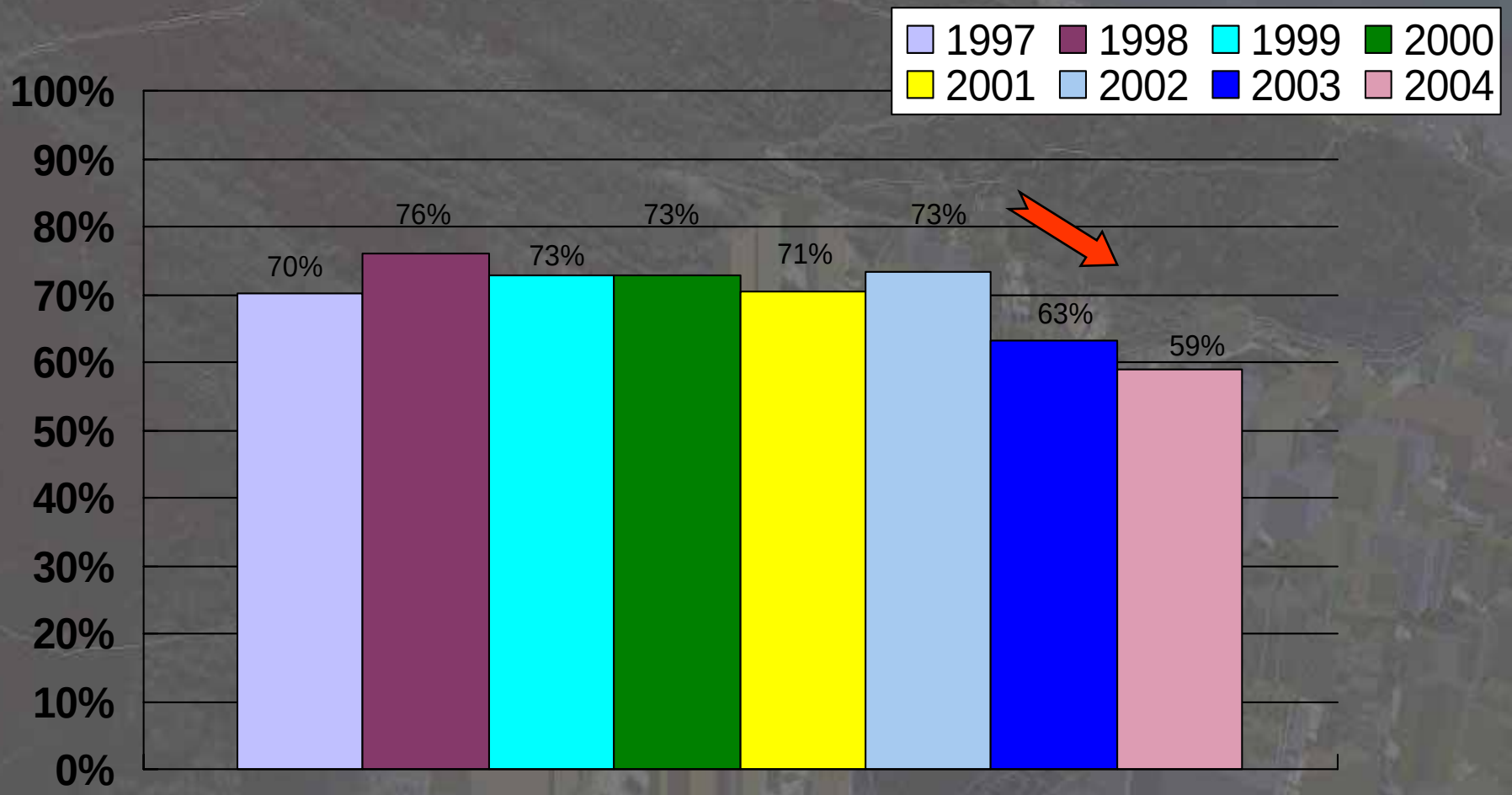
Public Education on Slope Safety – Exhibitions

Roving Exhibition

Landslide History Exhibition

Publicity of Landslide Risk & Importance of Slope Maintenance through TV - API

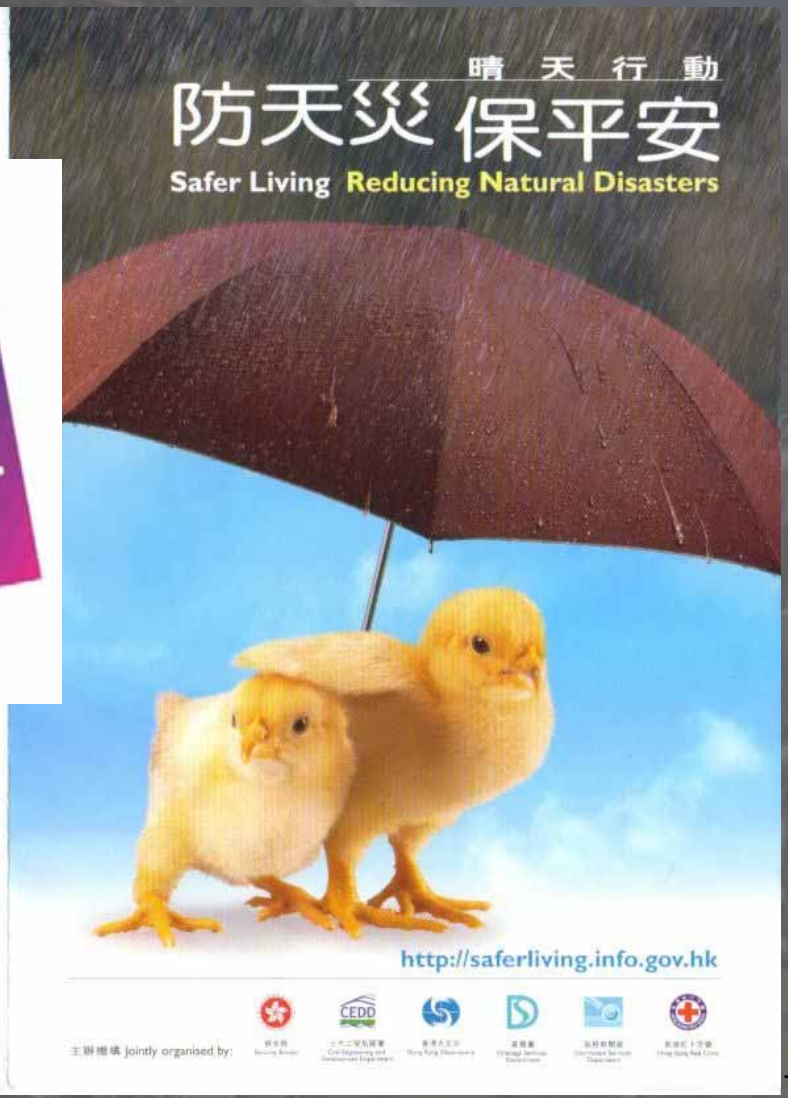
Concern on Slope Safety



Rolling Annual Public Education Campaign
"Safer Living – Reducing Natural Disasters"

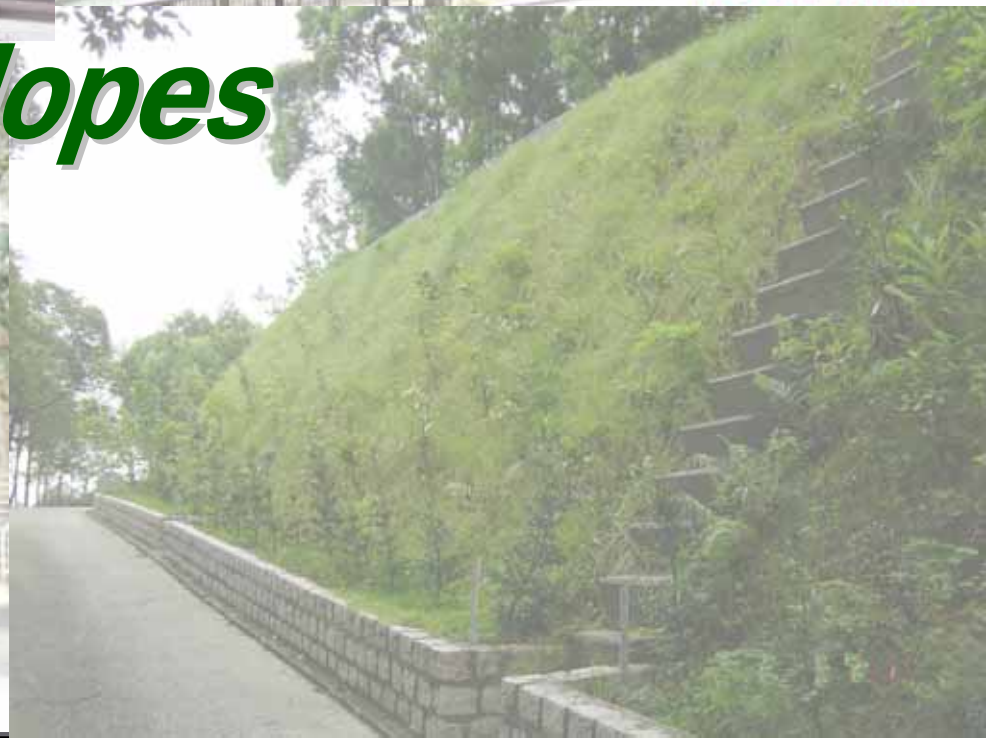
Apr 2005	• Entries to Tropical Cyclone Name Nomination Contest will be invited
	prevention in Hong Kong"
	• Announcement of results of Slogan and Bookmark Design Contest
Dec 2005	• Slope safety exhibition at a university
Jan 2006	• 24th — Popular Science Lecture VI "Rescue operation of Government Flying Service under adverse weather conditions"
Apr 2006	• 8th — Opening ceremony of a one-month major exhibition at Hong Kong Science Museum • 8th, 15th, 22nd & 29th — Rescue drill demonstrations by Hong Kong Red Cross, Auxiliary Medical Service, Civil Aid Service and Fire Services Department respectively at Lower Piazza of Hong Kong Science Museum

Reducing Natural Disasters
防天災 保平安
Safer Living 晴天行動



"Safer Living – Reducing Natural Disasters"
Exhibition of Natural Disasters to Raise Awareness

Enhance the Appearance of Slopes



Enhance the Appearance of Slopes

Examples of Shotcreted Slopes

Newspaper Articles on Slope Appearance in Late 1990s

Roadside slope policy just a shotcrete in the dark

...concrete are spoiling Hong Kong's natural scenery, says Edward Stoke

Eyeing slopes to stop shotcrete 'overkill'

We are closely involved in the debate about the widespread shotcreting of Hong Kong's roadside slopes; and we wish to respond to the letter from Mak Ka-wai, for the Secretary for Works, (*South China Morning Post*, April 30) concerning this issue. This high-level government response comes none too soon – for the shotcreting "overkill" has already seen the SAR's scenic...

Overseas experience shows that slopes steeper than 35 degrees, and even 55 degrees, can be effectively stabilised with plant cover.

The letter does not mention the widespread recent practice of covering solid roadside rock with skins of shotcrete so weak that they can be...

Policy was misguided

I would like to respond to a ...mber of letters and articles ...ppeared in these ...he South...

處理斜坡欠環保

陸恭蕙

綠化斜坡 噴草代噴漿

各種斜坡綠化方法指引

垂直擋土牆

60-70度斜坡
研究在斜坡面加建墊層保護鐵網層，中間注入泥土養草

55度斜坡
斜坡面加一層防侵蝕護墊保護泥土

砌磚圖案

預留小洞種植灌藤

35度以下斜坡
直接在斜坡面噴草及植樹

噴草

香港到處是人造斜坡，但光禿禿的噴漿混凝護土牆看來不環保也不美觀。為改善斜坡外觀，土木工程署現正制訂指引，要求各部門進行綠化斜坡政策，引入新技術，土木工程署每年種植二百五十個斜坡種植花草樹木。

土木工程署去年委託香港大學社會科研究中心，訪問市民對護土牆設計意見，結果六成受訪者認為，最佳方法是利

Government Policy

To make man-made slopes look as natural as possible to reduce their visual impact and improve the environment.

Works Bureau Technical Circulars

- WBTC No. 25/93 - Control of Visual Impact of Slopes
  - Contain policy guidance and design principles of slope works on control of visual impact of man-made slopes
- WBTC No. 17/2000 - Improvement to the Appearance of Slopes
  - Outlines the principles and procedures for improving slope appearance
  - Government departments involved in slope works are required to set up Vetting Committees on Slope appearance to control the use of shotcrete
- WBTC No. 14/2002 - Management and Maintenance of Natural Vegetation and Landscape Works, and Tree Preservation
  - Defines the management and maintenance responsibilities for natural vegetation and landscape works on slopes amongst others

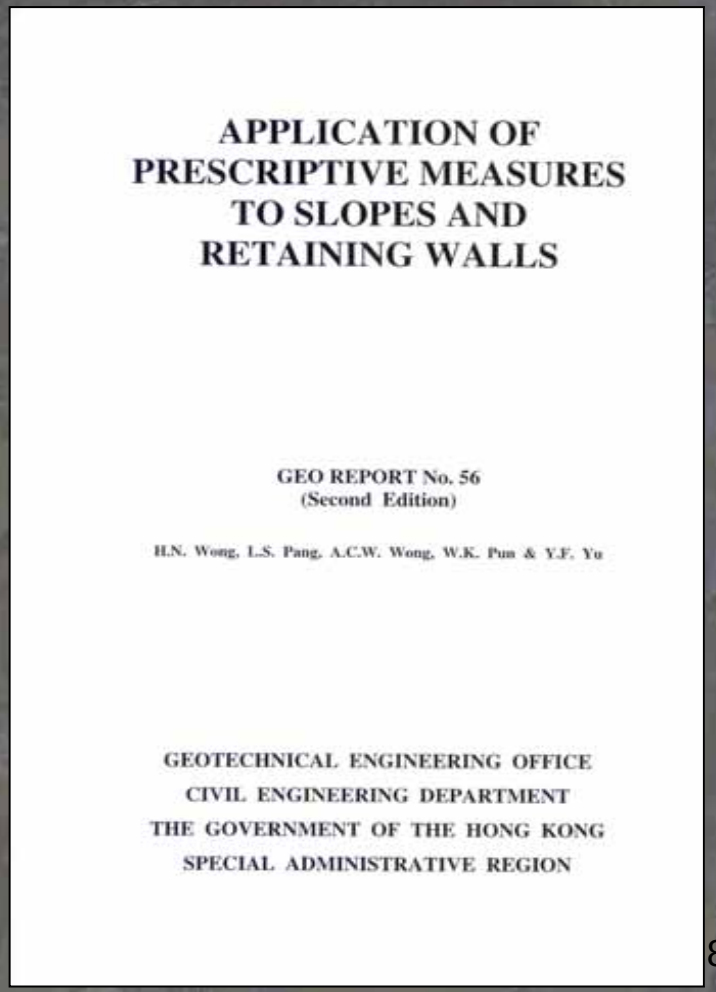
Initiatives

- Technical and administrative guidelines
- Promoting studies of greening technology
- LPM slopes - Targets and Measures


Technical and Administrative
Guidelines

GEO Report No. 56, 2nd Edition (1999) - Application of Prescriptive Measures to Slopes and Retaining Walls

- Contain guidelines on prescriptive use of vegetation cover to soil cut slopes up to 55°



APPLICATION OF
PRESCRIPTIVE MEASURES
TO SLOPES AND
RETAINING WALLS

GEO REPORT No. 56
(Second Edition)

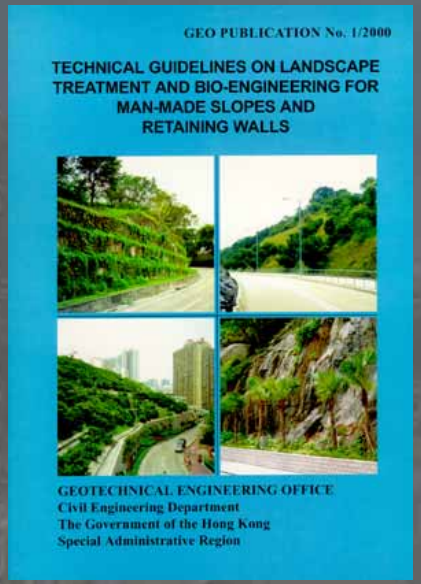
H.N. Wong, L.S. Pang, A.C.W. Wong, W.K. Pun & Y.F. Yu

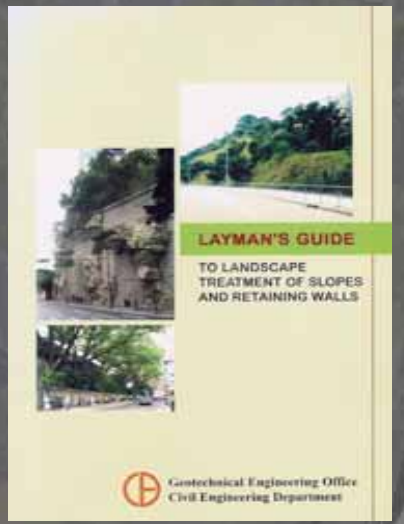
GEOTECHNICAL ENGINEERING OFFICE
CIVIL ENGINEERING DEPARTMENT
THE GOVERNMENT OF THE HONG KONG
SPECIAL ADMINISTRATIVE REGION

Changes in Local Practice

- Engagement of landscape specialists at design/construction stages of slope works
- A comprehensive technical guidelines published
- Policy Pledge to landscape Government slopes
- Layman's Guide to Landscape Treatment published

ADHOC → SYSTEMATIC INPUT

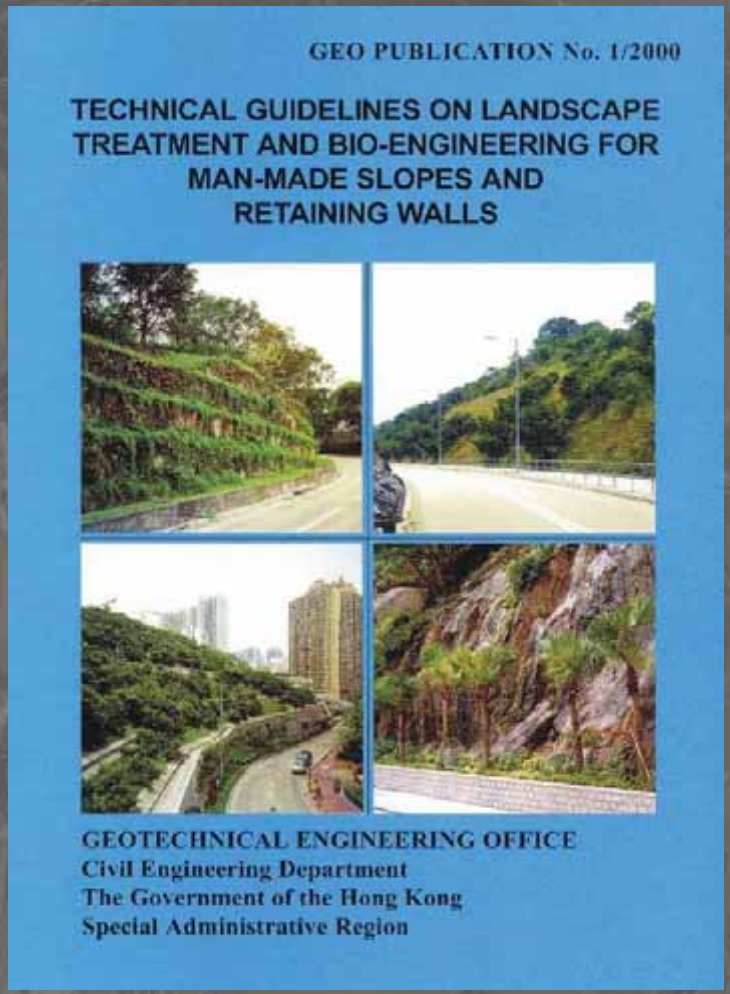




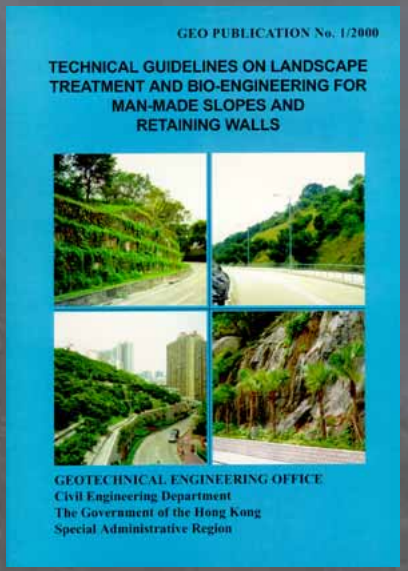
GEO Publication No. 1/2000

Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls

- **Provide guidance on good practice for landscape treatment and bio-engineering for man-made slopes and retaining walls**
  - design process
  - landscape design principles
  - worked examples
  - technical details
- **Aim for use by professionals**



Technical Guidelines



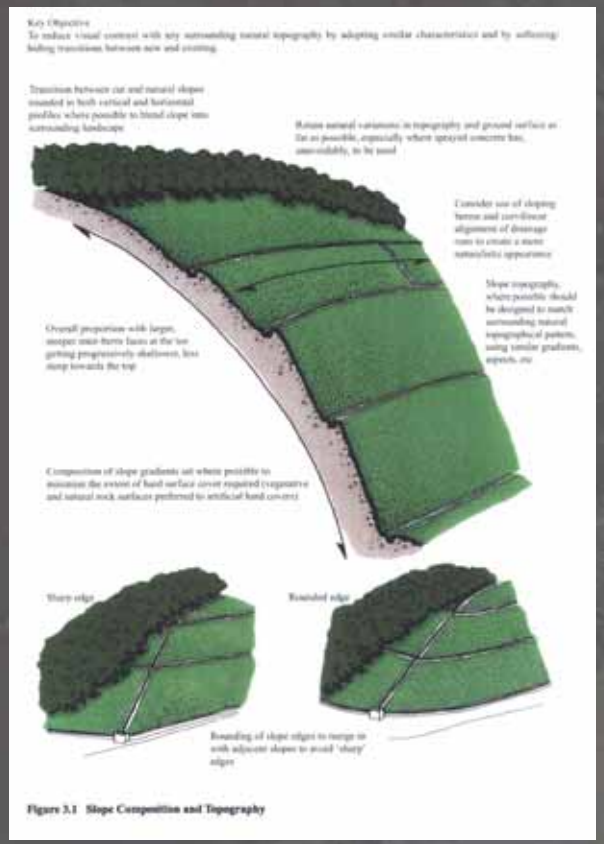


Figure 3.1 Slope Composition and Topography

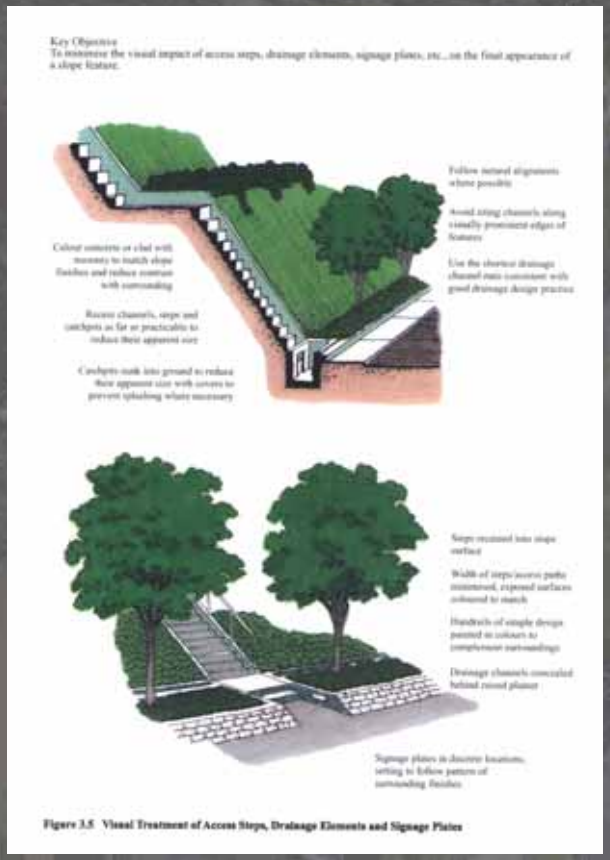


Figure 3.5 Visual Treatment of Access Steps, Drainage Elements and Signage Plates

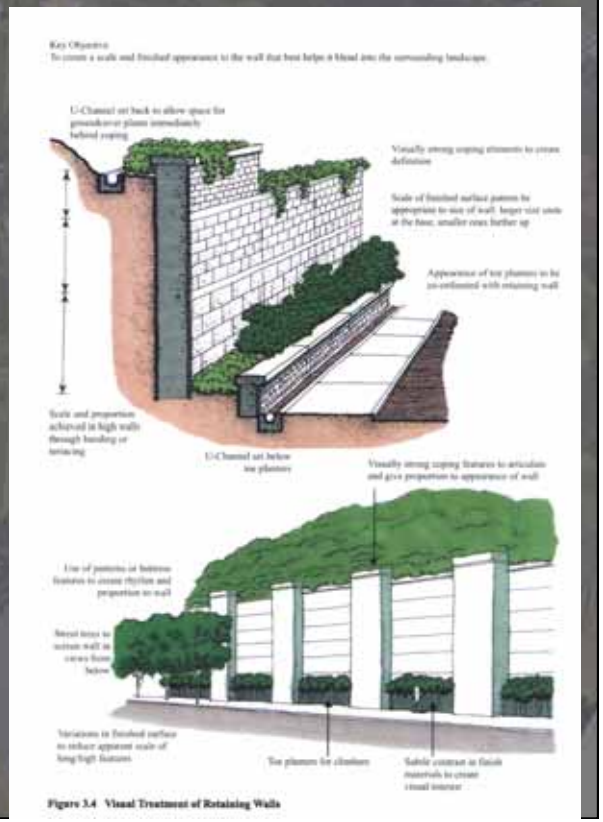


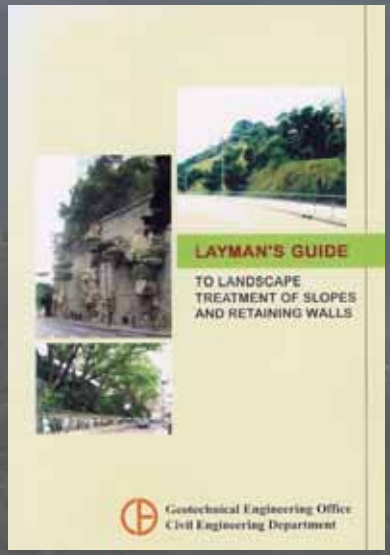
Figure 3.4 Visual Treatment of Retaining Walls

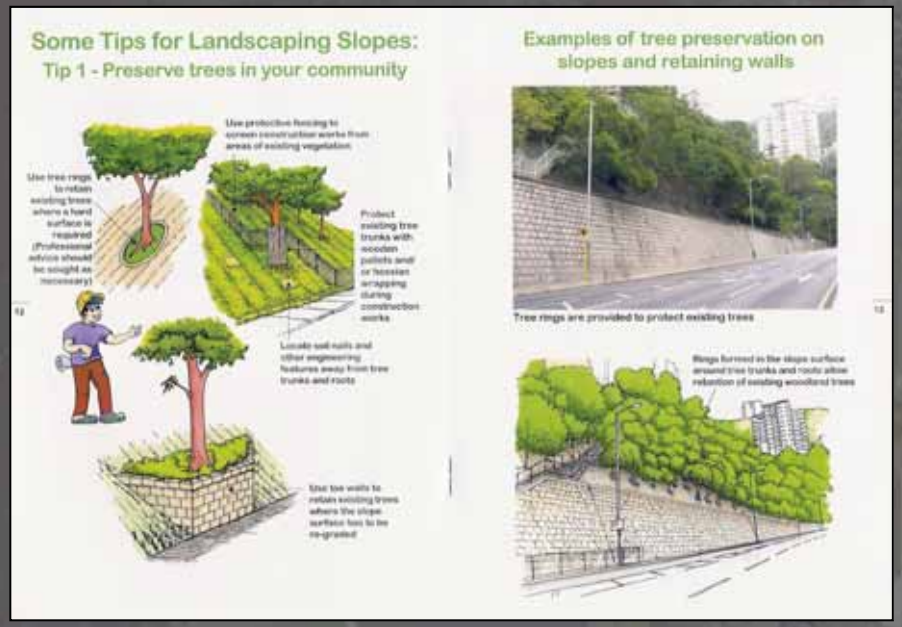
GEO Publication No. 1/2000

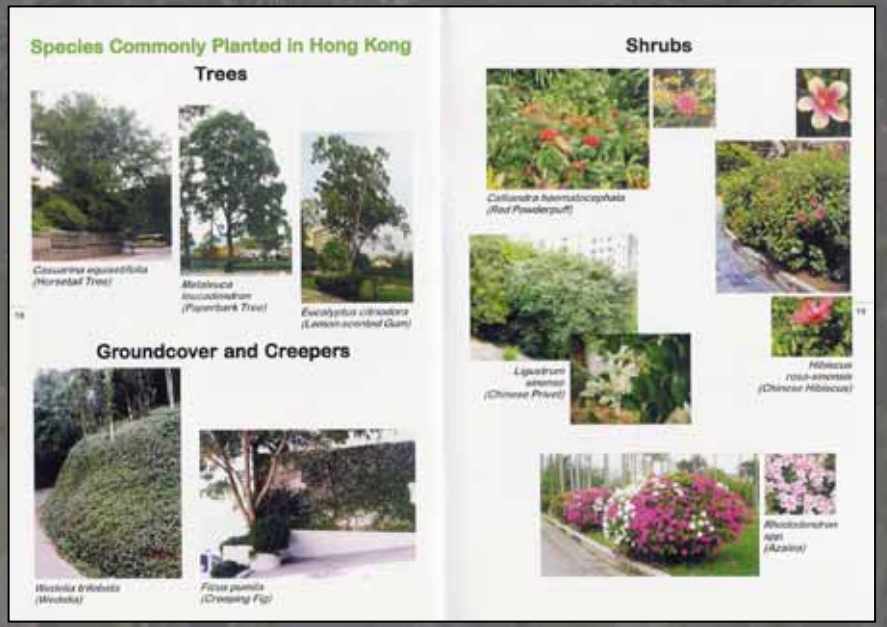
Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls

- Won a Silver Award under “Planning/Research” category and the Grand Award in the “Outstanding Green Project Awards 2000”

Layman's Guide to Landscape Treatment

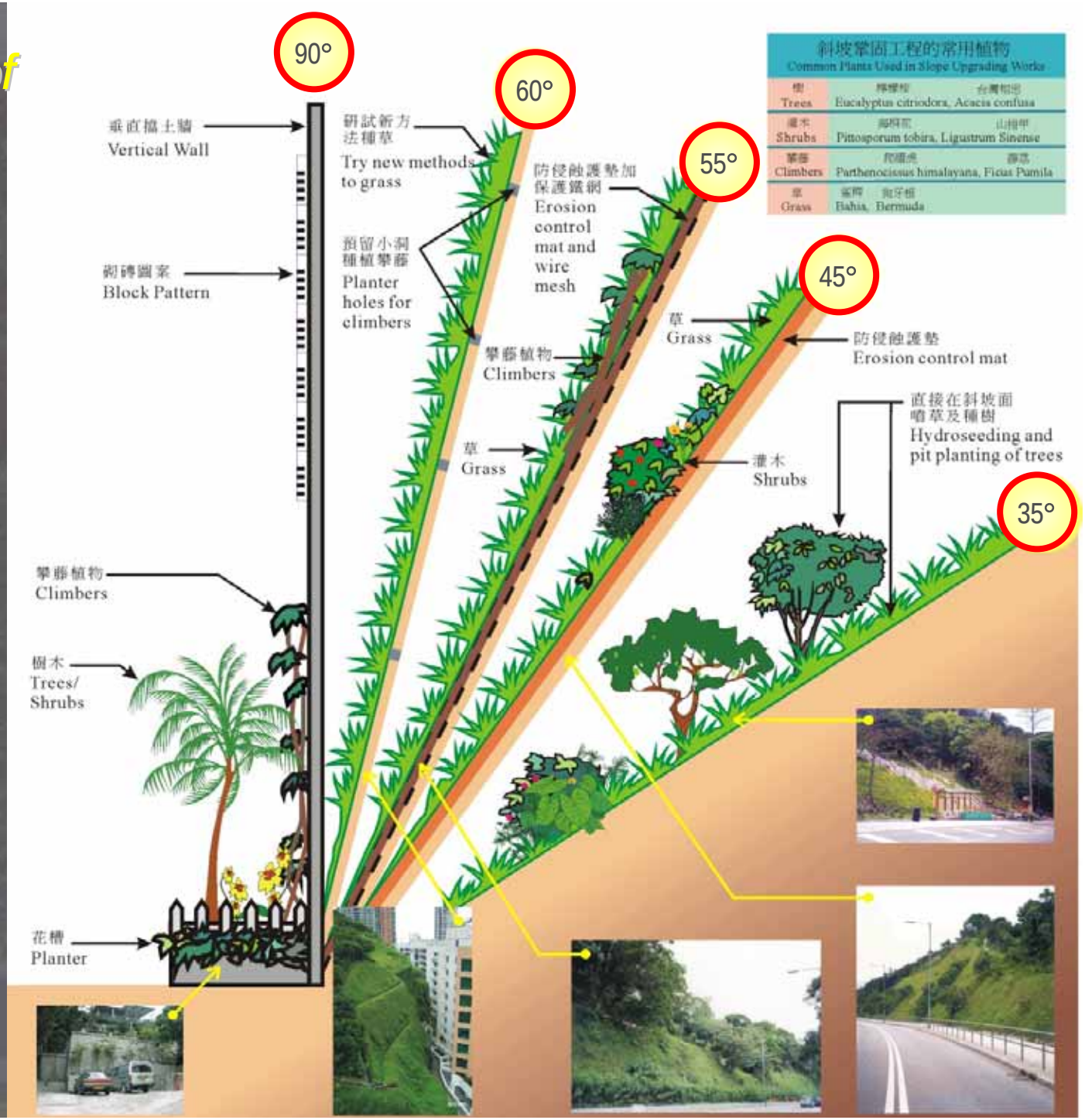






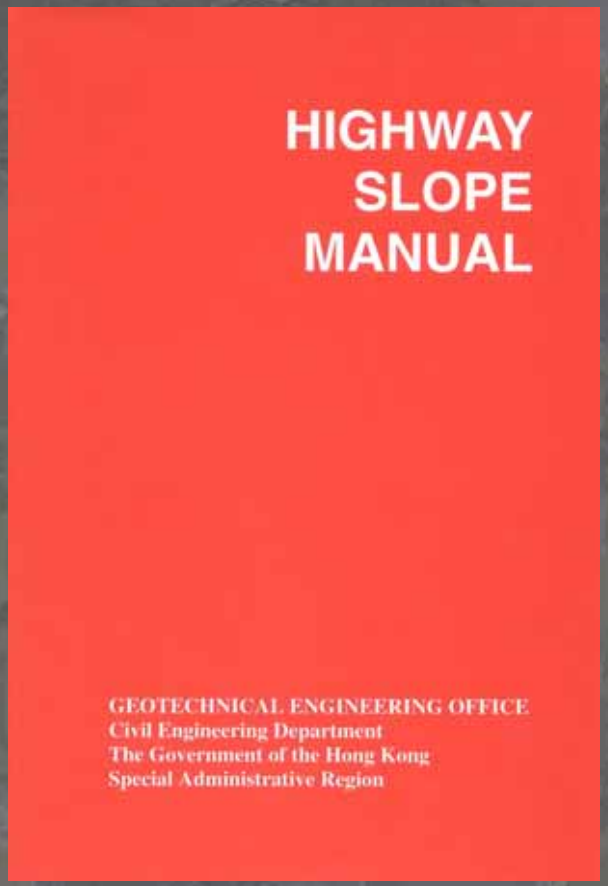
Common Methods of Vegetating Slopes

0 - 35°
35 - 45°
45 - 55°
55 - 60°
60 - 90°
90°



Highway Slope Manual (2000)

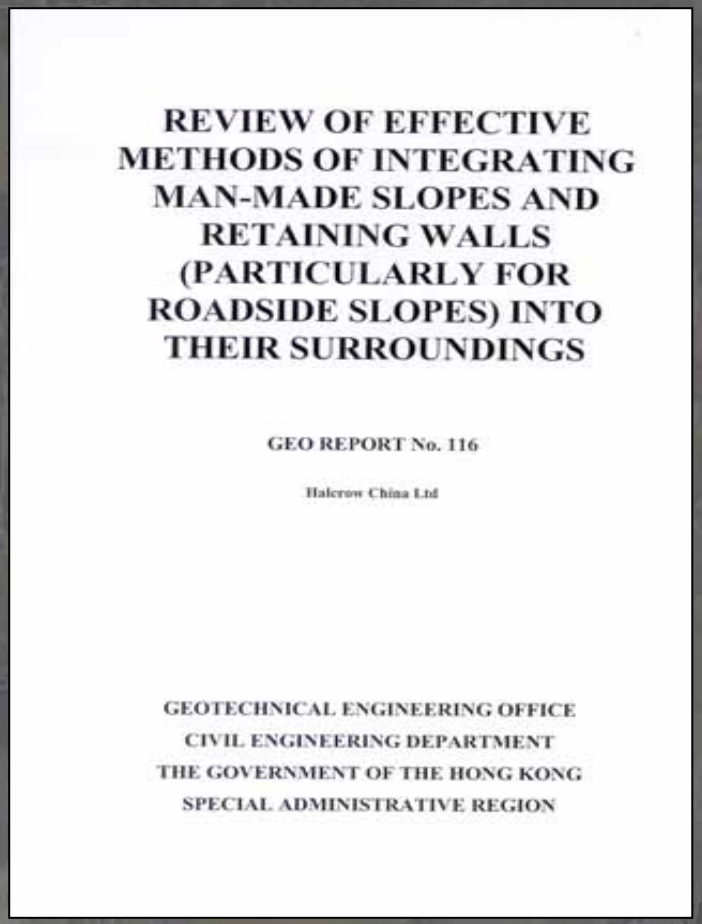
- Give guidance on good practice on planning, investigation, design, construction and maintenance of highway slopes
- Cover not only engineering aspects but also landscape aspects of slope design



GEO Report No. 116 (2001)

Review of Effective Methods of Integrating Man-made Slopes and Retaining Walls (Particularly for Roadside Slopes) into Their Surroundings

- Present a review of local and international practice into reduction of visual impact of slopes
- Give administrative and technical recommendations and proposals for further research



REVIEW OF EFFECTIVE METHODS OF INTEGRATING MAN-MADE SLOPES AND RETAINING WALLS (PARTICULARLY FOR ROADSIDE SLOPES) INTO THEIR SURROUNDINGS

GEO REPORT No. 116

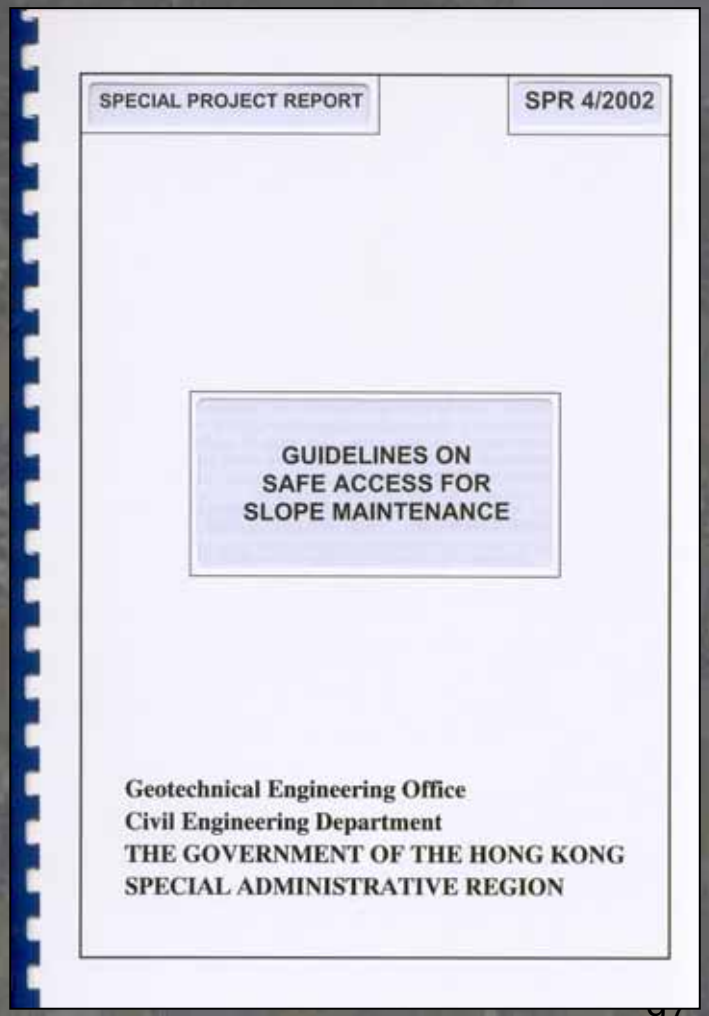
Halcrow China Ltd

GEOTECHNICAL ENGINEERING OFFICE
CIVIL ENGINEERING DEPARTMENT
THE GOVERNMENT OF THE HONG KONG
SPECIAL ADMINISTRATIVE REGION

Special Project Report SPR 4/2002
Guidelines on Safe Access for Slope Maintenance

- Present guidelines on the design of safe access for slope maintenance, taking into consideration visual quality amongst other aspects

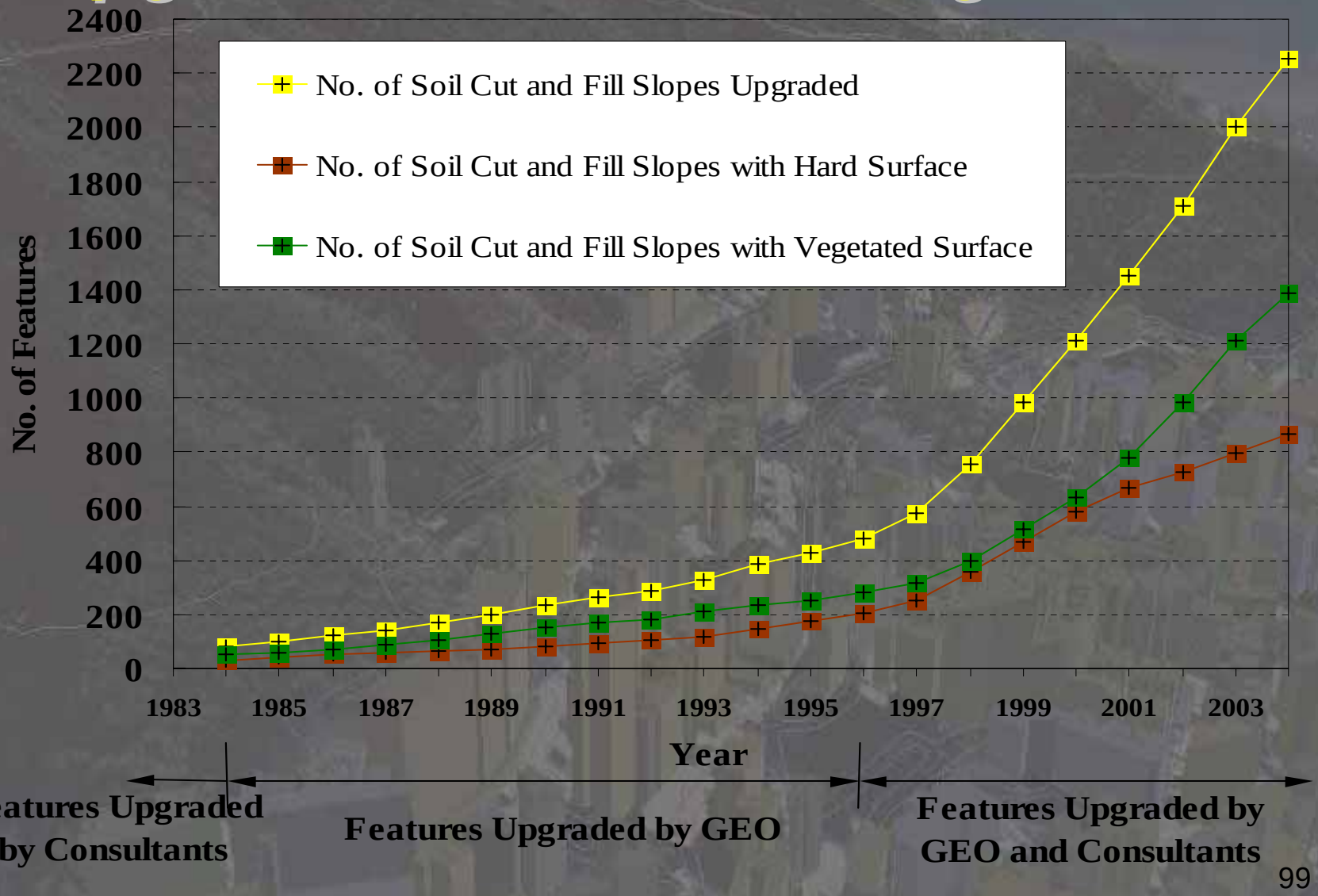
(GEO Rpt No. 136)



Various New Planting Techniques Are Used for Greening Steep Slopes

- Erosion control mat with steel wire mesh
- Mulching
- Grass in holes on shotcreted slope
- Soil-filled panels
- Fibrous soil
- Planter-grillage system, etc.

Surface Cover of Soil Cut & Fill Slopes Upgraded in the LPM Programme



Media and Public Appreciation of Improvement in Greening Slopes

Welcoming official's enlightened U-turn

The Secretary for Works and his peop
ought to be thanked for the recent
transformation of slope-stabilisation
policy, at least as viewed from Sai Ku

Last year, four government

植被代噴漿 環保引蟲鳥

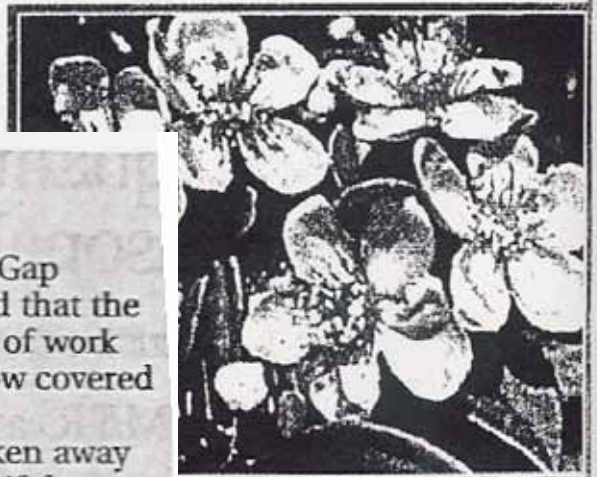
大嶼山 24 斜坡將披「綠衣」

山坡綠化計畫已成爲當局的改善環境政策，土力工程處新批出的山坡

律進行噴漿的做法，令山坡更翠綠。

助理署長(土力)防止山泥領導

當祥於簽署合約後表示，由於社會人士近年愈來愈注意斜坡的外觀，該處在山坡安全的前題下，銳意大規模進



土力處計畫在山坡上種植本地灌木和崗
(小圖)本地灌木毛栲(和崗栲)將種植在山
以達至美化目的。 資料圖片

SLOPE SUPPLEMENT

Safe slopes, green slopes

Slope safety and greening in Hong Kong

25 years into the Government's Landslip Preventive Measures (LPM) Programme, the Geotechnical Engineering Office (GEO) of the Civil Engineering Department (CED) is continuing to pick up the pace in ensuring Hong Kong's slopes are safe to the public.

The amount of work carried out under the Government's Landslip Preventive Measures (LPM) Programme has risen dramatically in recent years under an accelerated programme commencing in the mid-1980s. While about 35 slopes were upgraded each year from the late 1970s to the mid-1980s at an average annual cost of HK$60 million, works received a significant boost under the five-year Accelerated LPM Project from 1985-2000. During this period, some 800 Government substandard features were upgraded as part of the LPM project. The total cost of the project was about HK$2.6 billion. A new ten-year Extended LPM Project (that Government departments who follow up with long-term maintenance. The seven departments are Highways Department, Housing Department, Lands Department, Water Supplies Department, Drainage Services Department, Architectural Services Department and Agriculture, Fisheries and Conservation Department.

In designing upgrading works for the three main types of man-made features — cut slopes, fill slopes and retaining walls — the GEO/CED pays attention not only to the stability aspects but also to the appearance of the finished work.

Job well done

Driving along Wong Nei Chung Gap Road and Stubbs Road, I noticed that the slopes that had undergone a lot of work during the winter months are now covered with lush green grass.

Once the mesh covers are taken away the hillside will look really beautiful.

I would like to praise the relevant government department for doing a great job this time. Planting grass makes such

試種灌木美化斜坡

【商報專訊】記者古日東報道：土木工程署轄下土力工程處正試驗在陡峭的斜坡上種植灌

該署土力工程師蔡炯照表示，選擇種植本地植物，是要考慮到對本港生態的影響，而所選

Public Opinion

- **Public opinion survey in 2004**
  - 65% satisfied with slope appearance

- Survey with District Councils (July 2002)
  - 63% neither satisfied nor dissatisfied with slope appearance
  - 31% quite satisfied with slope appearance
  - Slope greening should be further promoted

Promoting Studies in Greening Technology

Greening Technology

- **Performance Assessment of Greening Techniques and Vegetation Species on Slopes**
- **Trial Planting of Native Shrubs on Steep Slopes**

Performance Assessment of Greening Techniques and Vegetation Species on Slopes

(August 2002 - December 2003)

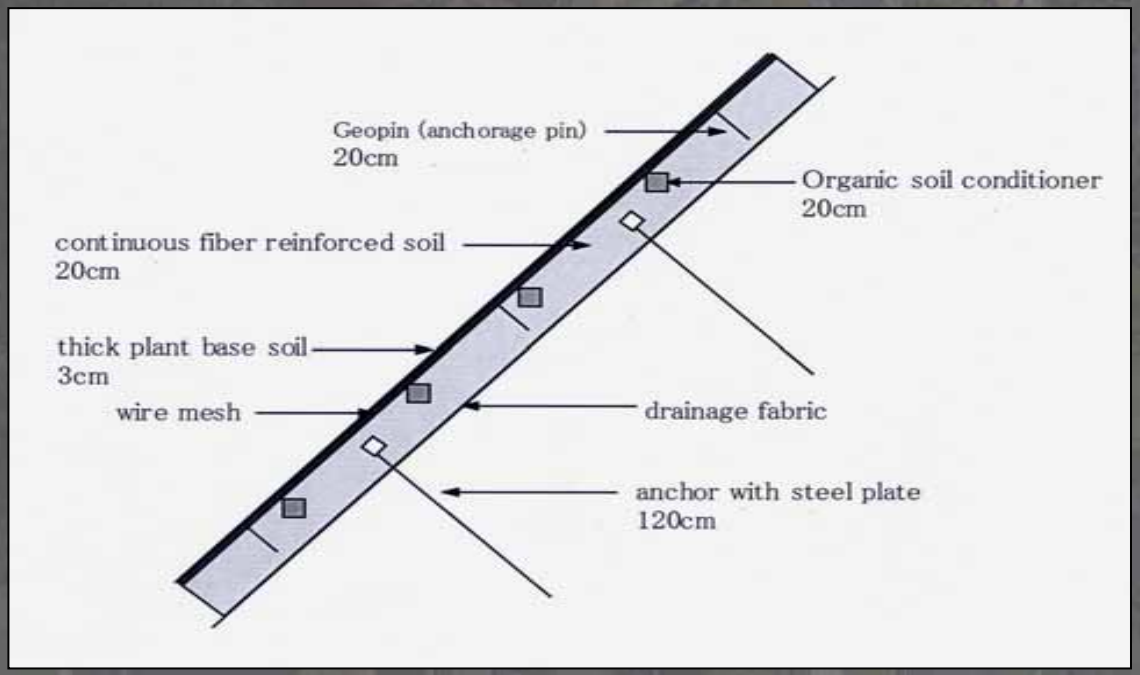
- **Task 1 - Assessing the performance of greening techniques**
  - Common Database on Greening Techniques
  - Inspect 100 slope features
  - Assess the performance

- **Task 2 - Assessing the performance of vegetation species**
  - Inspect 20 slope features
  - Assess the performance of both planned species and unplanned species, aiming to identify a list of vegetation species that are self-sustaining on steep slopes

Performance Assessment of Greening Techniques on Slopes

Greening product : Geofiber

- **A kind of Fiber Reinforced Soil method based on continuous fiber soil reinforcement technology**
- **Can be applied to slopes with gradient up to 70°**



Performance Assessment of Greening Techniques on Slopes

Greening product : Geofiber

Feature 11SW-B/C 24 at Stubb's Road

Performance Assessment of Vegetation Species on Slopes

A well-vegetated slope

Feature 11NW-A/C56 at Ching Cheung Road

Performance Assessment of Vegetation Species on Slopes

Gordonia axillaris
(Gordonia 大頭茶)

Rhus hypoleuca
(Sumac 白背鹽膚木)

Passiflora foetida
(Passion flower 龍珠果)

Millettia nitida
(Millettia 亮葉崖豆藤)

Trial Planting of Native Shrubs on Steep Slopes (July 2001 - July 2006)

- **Undertake trial planting of 8 native shrub species on 2 steep (55˚) soil slopes in collaboration with the Kadoorie Farm and Botanic Garden**
- **Aim to study**
  - Growth of native shrubs
  - Natural succession of plants
  - Effect of surface protection provided by native shrubs
- **Shrubs having a lower risk of uprooting are more suitable for planting on steep slopes**
- **Native species are beneficial for ecological enhancement**
- **Species selected are hardy**
- **The survival and growth rate of the shrubs are satisfactory so far**

Trial Planting of Native Shrubs on Steep Slopes

Trial site : Yuen Tun at Tai Lam Country Park

Condition in August 2001

Condition in 2005

Trial Planting of Native Shrubs on Steep Slopes

Shrub planting

Vegetation monitoring

Trial site : Yuen Tun at Tai Lam Country Park

Trial Planting of Native Shrubs on Steep Slopes

Psychotria asiatica
(Wild Coffee 山大刀)

Melicope pteleifolia
(Evodia 三椏苦)

Litsea rotundifolia
(Long-leaf Litsea 豺皮樟)

Schefflera octophylla
(Ivy Tree 鴨腳木)

Trial Planting of Native Shrubs on Steep Slopes

Gordonia axillaris
(Gordonia 大頭茶)

Zanthoxylum avicennae
(Prickly Ash 簕欓)

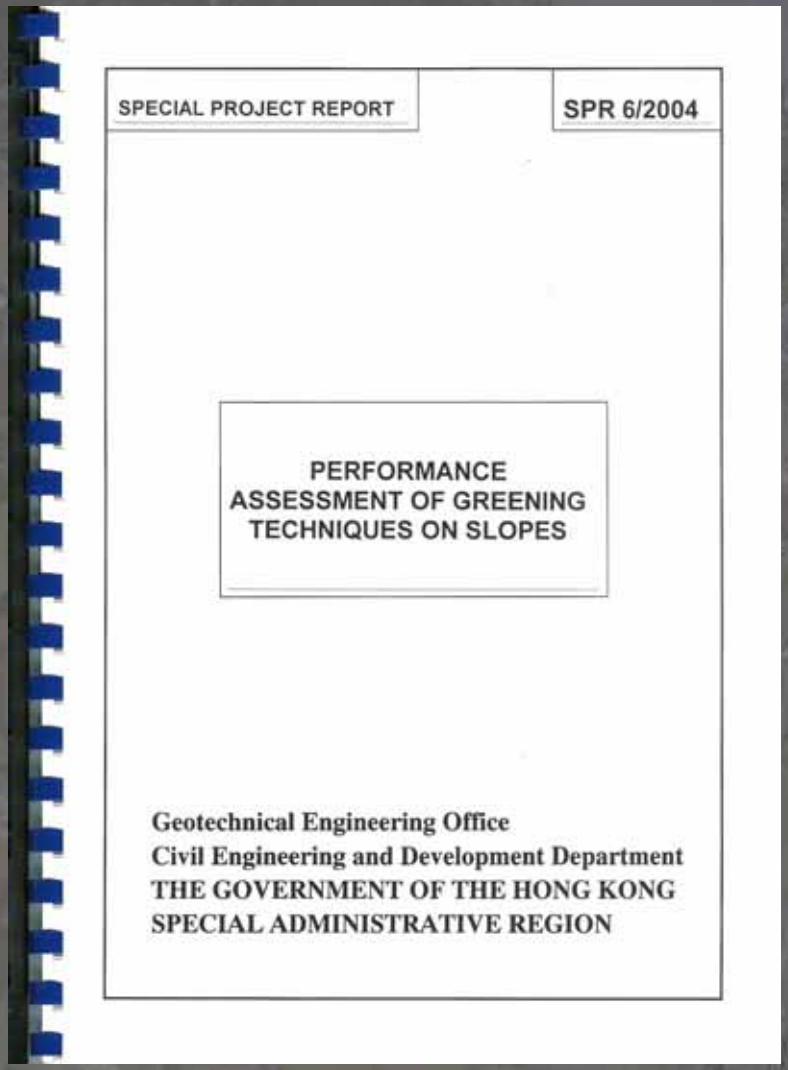
Ardisia crenata
(Hilo Holly 大羅傘)

Rhaphiolepis indica
(Hong Kong Hawthorn 車輪梅)

Special Project Report SPR 6/2004
Performance Assessment of Greening Techniques on Slopes

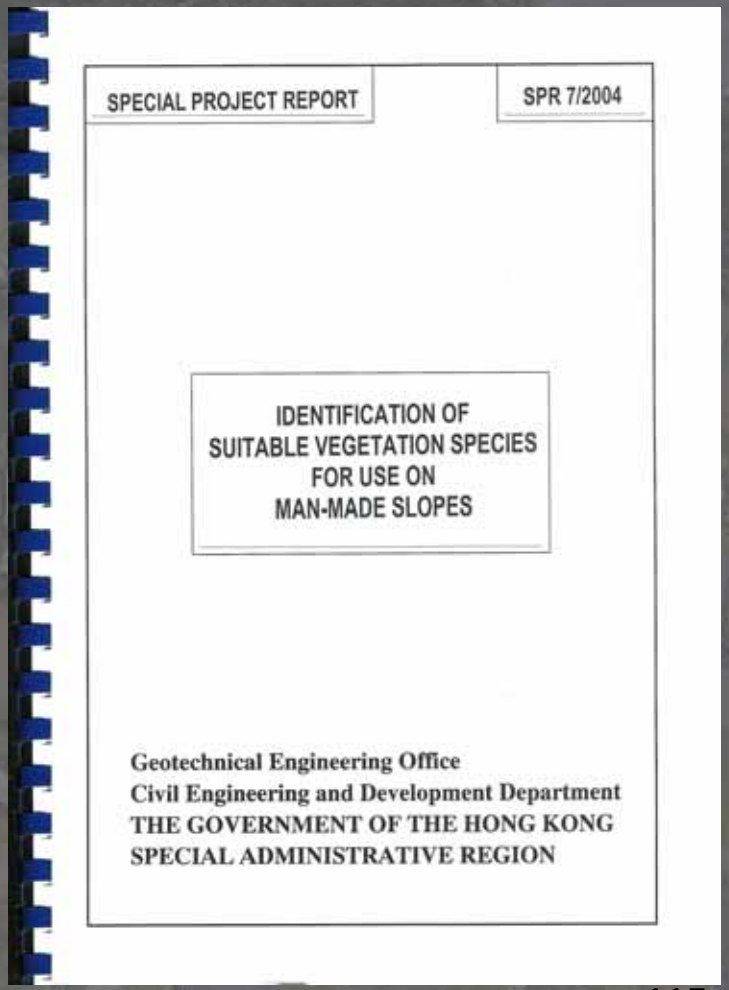
- Present findings on performance of various greening techniques applied on 100 slopes.
- Recommend improvements to different areas on the application of the greening techniques.

(GEO Rpt No. 183)



Special Project Report SPR 7/2004
Identification of Suitable Vegetation Species for Use on Man-made Slopes

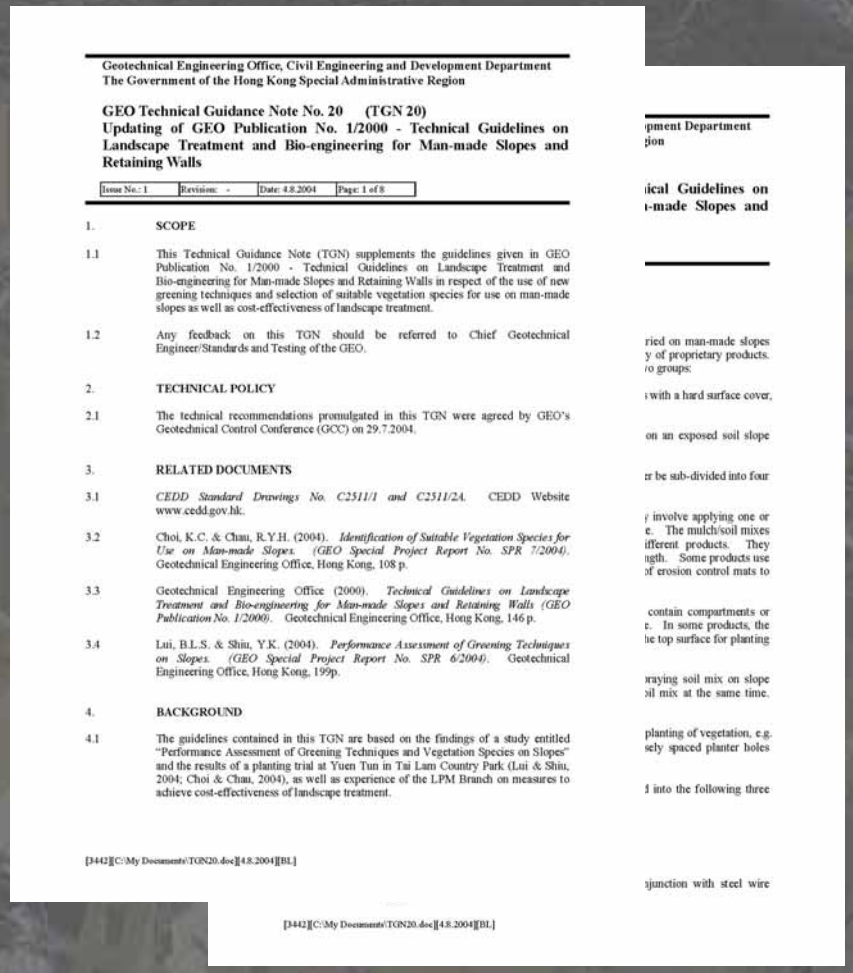
- Present findings on the planting trial of 8 native small tree and shrub species at Yuen Tun.
- Present findings of the performance assessment of vegetation species on 20 well-vegetated cut slopes.
- Recommend a list of native vegetation species that have been proven successful and reliable.



GEO Technical Guidance Note No. 20

Updating of GEO Publication No. 1/2000 – Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls

- Supplement the guidelines given in the GEO Publication No. 1/2000 in respect of the use of new greening techniques and selection of suitable vegetation species.



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

GEO Technical Guidance Note No. 20 (TGN 20)
Updating of GEO Publication No. 1/2000 - Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls

Issue No.: 1	Revision: -	Date: 4.8.2004	Page: 1 of 8

1. **SCOPE**

1.1 This Technical Guidance Note (TGN) supplements the guidelines given in GEO Publication No. 1/2000 - Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls in respect of the use of new greening techniques and selection of suitable vegetation species for use on man-made slopes as well as cost-effectiveness of landscape treatment.

1.2 Any feedback on this TGN should be referred to Chief Geotechnical Engineer/Standards and Testing of the GEO.

2. **TECHNICAL POLICY**

2.1 The technical recommendations promulgated in this TGN were agreed by GEO's Geotechnical Control Conference (GCC) on 29.7.2004.

3. **RELATED DOCUMENTS**

3.1 *CEDD Standard Drawings No. C2511/1 and C2511/2A.* CEDD Website www.cedd.gov.hk.

3.2 Choi, K.C. & Chau, R.Y.H. (2004). *Identification of Suitable Vegetation Species for Use on Man-made Slopes. (GEO Special Project Report No. SPR 7/2004).* Geotechnical Engineering Office, Hong Kong, 108 p.

3.3 Geotechnical Engineering Office (2000). *Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (GEO Publication No. 1/2000).* Geotechnical Engineering Office, Hong Kong, 146 p.

3.4 Lui, B.L.S. & Shiu, Y.K. (2004). *Performance Assessment of Greening Techniques on Slopes. (GEO Special Project Report No. SPR 6/2004).* Geotechnical Engineering Office, Hong Kong, 199p.

4. **BACKGROUND**

4.1 The guidelines contained in this TGN are based on the findings of a study entitled "Performance Assessment of Greening Techniques and Vegetation Species on Slopes" and the results of a planting trial at Yuen Tun in Tai Lam Country Park (Lui & Shiu, 2004; Choi & Chau, 2004), as well as experience of the LPM Branch on measures to achieve cost-effectiveness of landscape treatment.

[3442][C:\My Documents\TGN20.doc][4.8.2004][BL]

[3442][C:\My Documents\TGN20.doc][4.8.2004][BL]

LPM Slopes - Targets and Measures

Annual Targets since 2002

- **To landscape all the 250 slopes upgraded under the LPM Programme**

- **At least 70% of the LPM slopes upgraded to have vegetation cover**

Measures

- **Include landscape treatment as an integral part of slope upgrading works**
  - Cost of landscape works is 10-20% of cost of slope upgrading works
  - Cost of greening works is comparable to cost of hard surfacing covers
- **Engage landscape consultants**
- **Establish the posts of a Landscape Architect and a Field Officer**
- **Organise training courses for professional staff and site staff**
- **Publicise the best landscaped feature of the month**

Examples of Good Landscaped Features

- **Cut slopes**
  - 11NW-B/C 121 at Lung Ping Road, Sham Shui Po
- **Fill slopes**
  - 11NE-D/FR 284 at Ma Yau Tong, Sai Kung
- **Rock slopes**
  - 11SE-C/C 161 at Mt. Parker Road
- **Retaining walls**
  - 11SW-A/R 159 at Conduit Road
  - 7SE-C/R 88 at Ngau Pei Sha New Village, Shatin

Cut Slopes

Before works

After works

- Cutting back
- Soil nails
- Hydroseeding and shrub planting
- Toe planter

Feature 11NW-B/C121 at Lung Ping Road, Sham Shui Po

Fill Slopes

Before works

After works

- Retaining wall
- Rock fill compaction
- Hydroseeding and shrub planting

Feature 11NE-D/FR284 at Ma Yau Tong, Sai Kung

Rock Slopes

Before works

After works

- Rock slope stabilisation
- Buttress wall
- Artificial rock

Feature 11SE-C/C161at Mt. Parker Road

Retaining Walls

Before works

After works

- Soil nails
- Preservation of wall tree
- Retention of original wall appearance

Feature 11SW-A/R 159 at Conduit Road

Retaining Walls

Before works

After works

- Skin wall and masonry facing
- Toe planters of varying heights

Feature 7SE-C/R88 at Ngau Pei Sha New Village, Shatin

Ecological Consideration

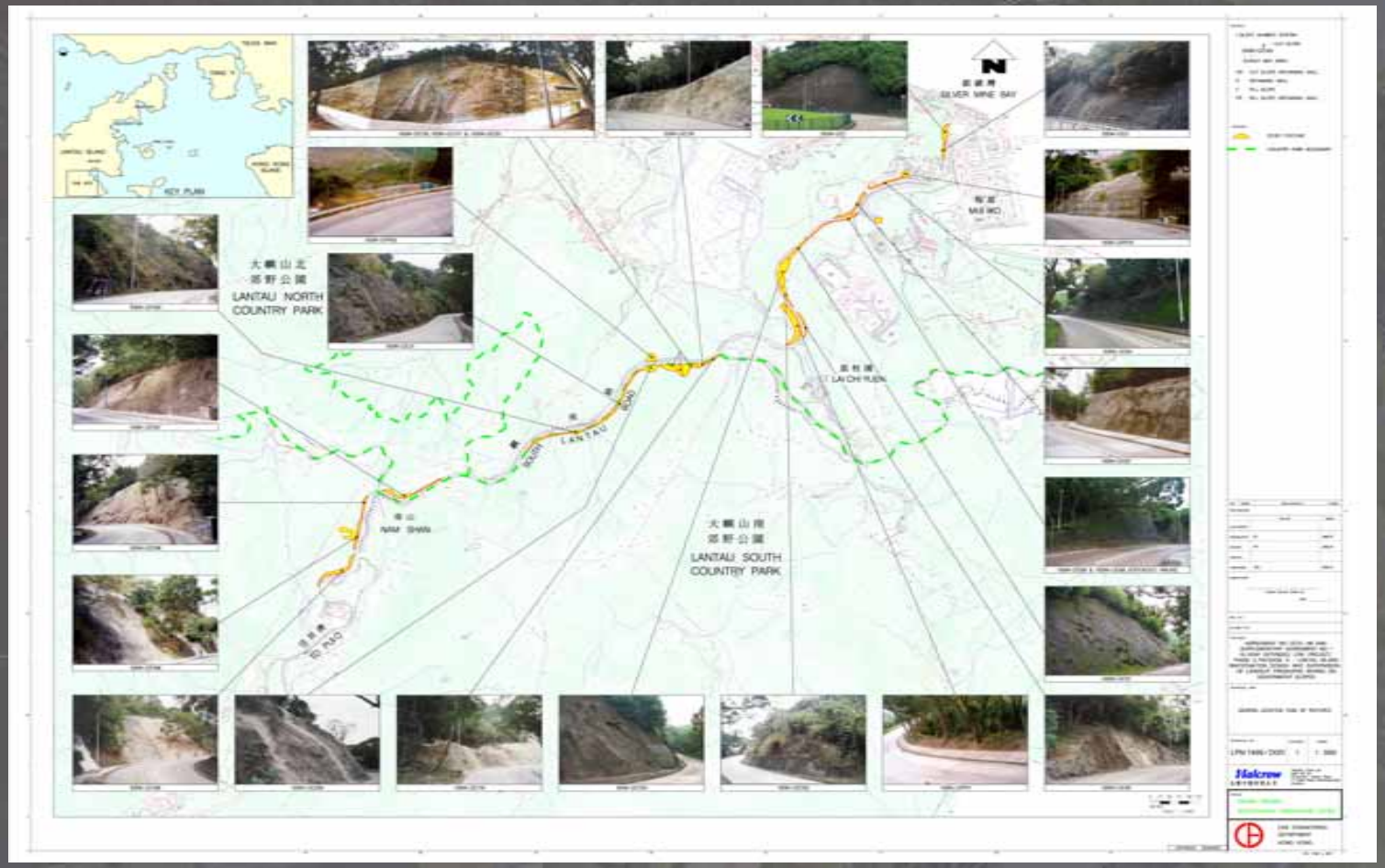
- A biodiversified vegetation cover is ecologically stable and hence more sustainable.
- Efforts are devoted to achieve ecological enhancement on slopes by:
  - Adopting native species for restoring vegetation covers as far as possible
  - Protecting any rare plant species found on or in close proximity to the slopes to be upgraded under the LPM Programme


Projects Demonstrating Efforts on
Ecological Considerations

Project 1
Slope Upgrading Works along South Lantau Road between Mui Wo and Pui O, Lantau (December 2001 - Early 2004)

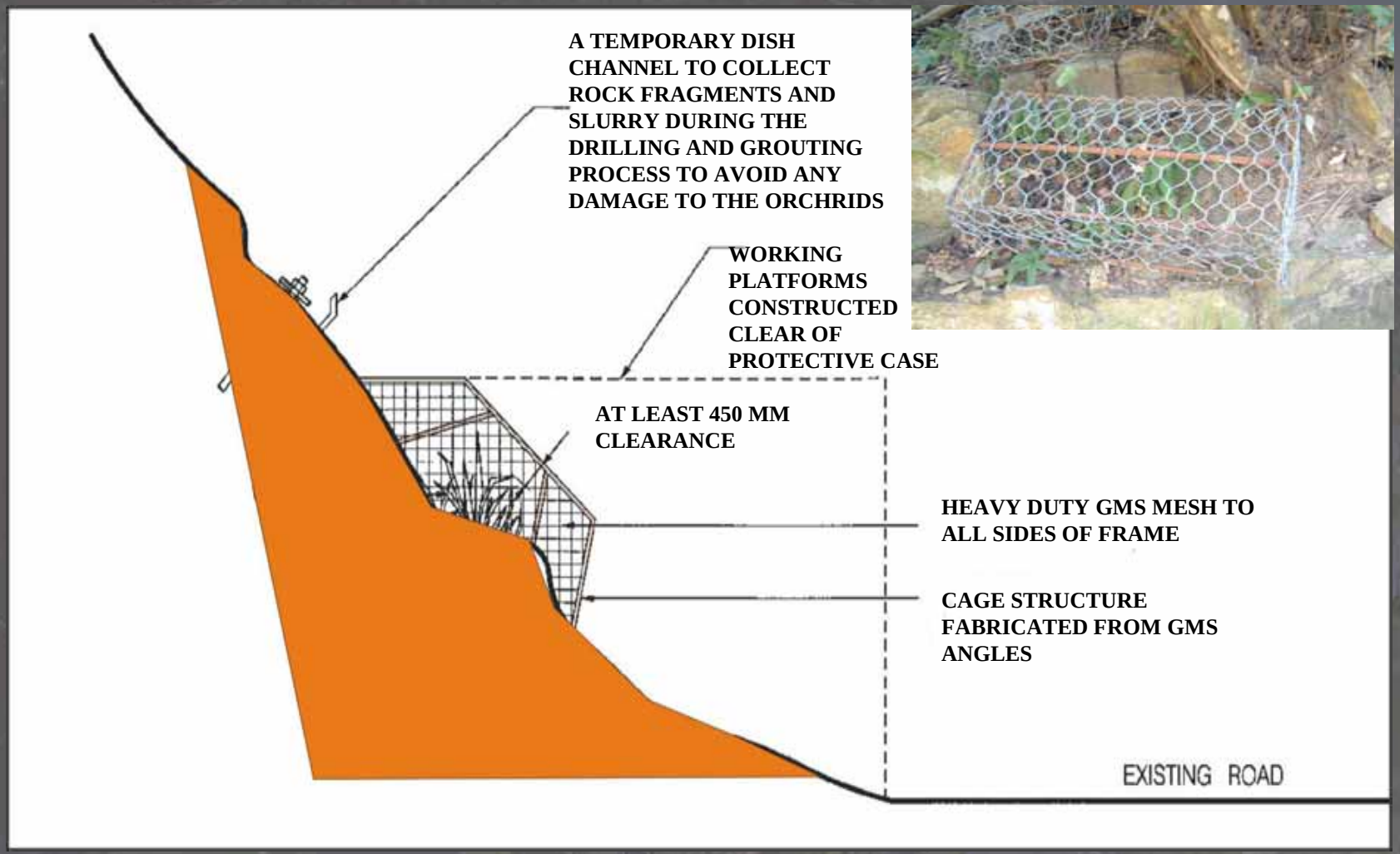
- **Involved 24 slope features**
- **Ecological survey carried out for 12 slope features within Lantau South and Lantau North Country Parks according to EIAO**
- **Wild orchids classified as locally protected species found on 2 slope features**
  - Cages installed to protect the orchids during slope upgrading works
- **Original hard surface covers on all slope features replaced by vegetation**
- **Native species planted to enhance the ecological value of vegetation covers**

Slope upgrading works along South Lantau Road between Mui Wo and Pui O, Lantau



Locations of 24 Slope Features at South Lantau Road

Slope upgrading works along South Lantau Road between Mui Wo and Pui O, Lantau



Measures for Protecting Wild Orchids

Slope Upgrading Works along South Lantau Road between Mui Wo and Pui O, Lantau

Before works

Landscape design

After works

Feature 10SW-C/C1

Slope Upgrading Works along South Lantau Road between Mui Wo and Pui O, Lantau

Feature 10SW-C/FR70

After works

Slope Upgrading Works along South Lantau Road between Mui Wo and Pui O, Lantau

Feature 10SW-C/C165

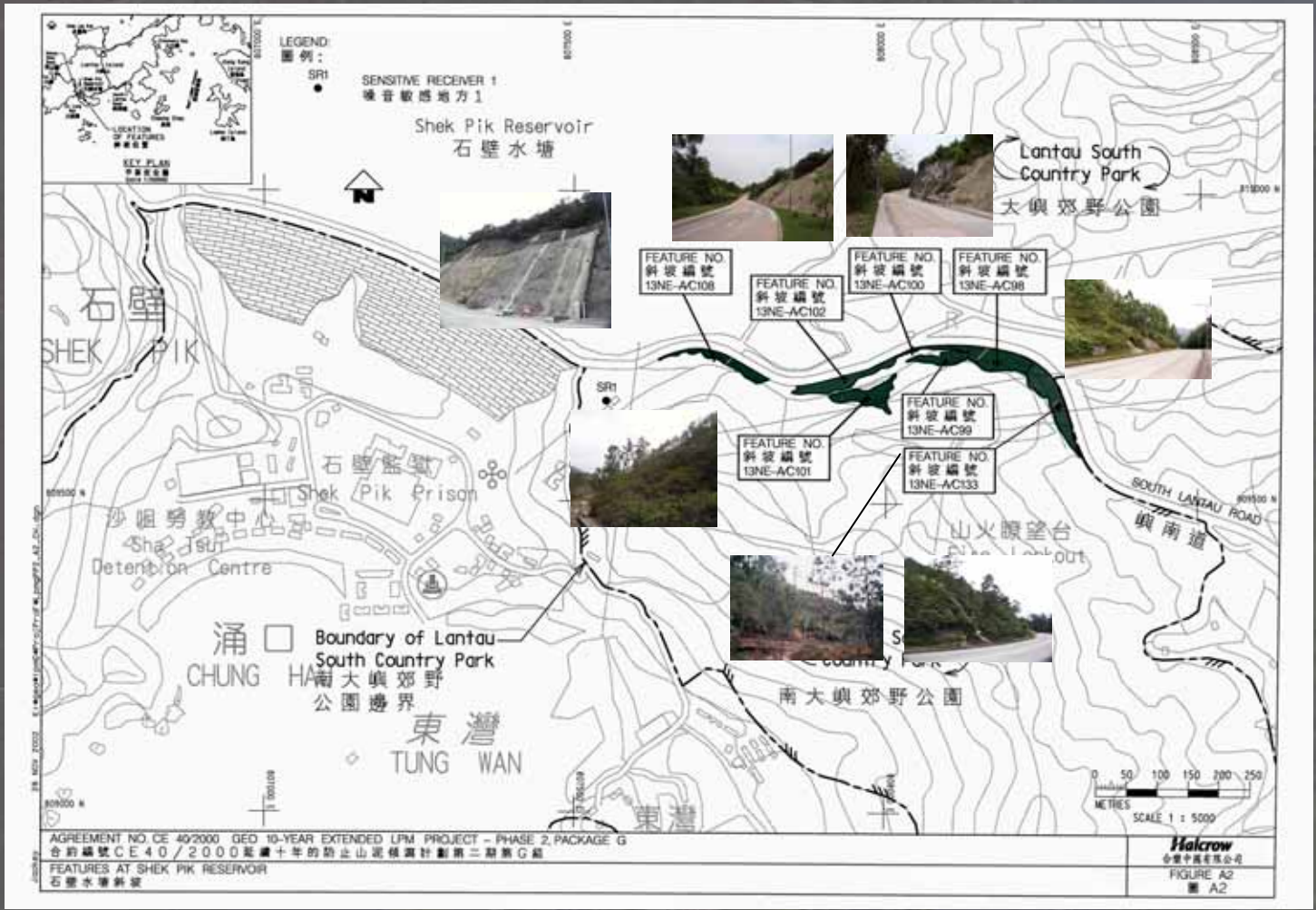
After works

Project 2

Slope Upgrading Works along Keung Shan Road and South Lantau Road near Shek Pik Reservoir, Lantau (March 2003 - Early 2005)

- **Involved 9 slope features**
- **Ecological survey carried out for these 9 slope features, all within Lantau South Country Park, according to EIAO**
- **Chinese New Year flower (*Enkianthus quinqueflorus*) classified as locally protected species found on a slope feature at Keung Shan Road**
  - Those not affected to be protected by chain link fence
  - Those affected to be transplanted by specialist landscape contractor
- **Original hard surface covers on 5 slope features replaced by vegetation**
- **Native species planted to enhance the ecological value of vegetation covers**

Slope Upgrading Works along Keung Shan Road and South Lantau Road near Shek Pik Reservoir, Lantau



Locations of 7 Slope Features at South Lantau Road

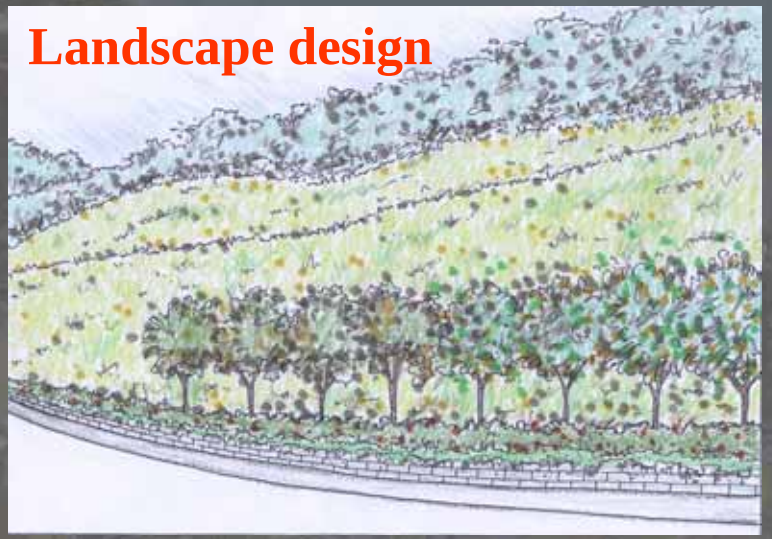
Slope Upgrading Works along Keung Shan Road and South Lantau Road near Shek Pik Reservoir, Lantau

Locations of 2 Slope Features at Keung Shan Road

Slope Upgrading Works along Keung Shan Road and South Lantau Road near Shek Pik Reservoir, Lantau

Chinese New Year Flower (*Enkianthus quinqueflorus*)

Slope upgrading works along Keung Shan Road and South Lantau Road near Shek Pik Reservoir, Lantau



Feature 13NE-A/C108 at South Lantau Road

After works


Questions?


BREAK