



# Geotechnical Services



A flexible barrier protecting Tung Chung Road



## INTRODUCTION

The Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) is responsible for a wide range of geotechnical engineering activities related to the safe and economic utilisation and development of land.

The GEO operates on the basis of 11 Divisions under the direction of the Head of Geotechnical Engineering Office and provides the following geotechnical engineering services:

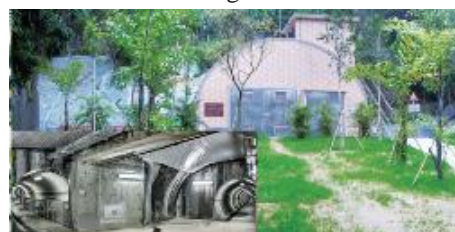


Po Shan Road and Kotewall Road Landslide in 1972

## GEOTECHNICAL CONTROL AND LAND USE PLANNING

One of the GEO's major slope safety regulatory functions is to audit the design of geotechnical works to ensure they meet current safety standards. Geotechnical auditing is exercised largely through our 3 District Divisions: Island, Mainland East and Mainland West Divisions. Each District Division is responsible for a geographical region of Hong Kong.

The scope of auditing covers the design and construction of the geotechnical aspects of all building developments and civil engineering works. In particular, the District Divisions audit the site formation works, slope upgrading works, deep excavations, tunneling works, caverns and foundation works in areas with cavernous marble or complex geological conditions that are designed and constructed by the private sector, public authorities and government departments to an adequate standard of geotechnical risk management.



The Groundwater Drainage System of Po Shan Road was constructed to control the groundwater levels for reducing the risk of major landslides



Greening measures on concrete rigid barrier at North Lantau Highway



Slope upgrading works with greening measures at South Lantau Road

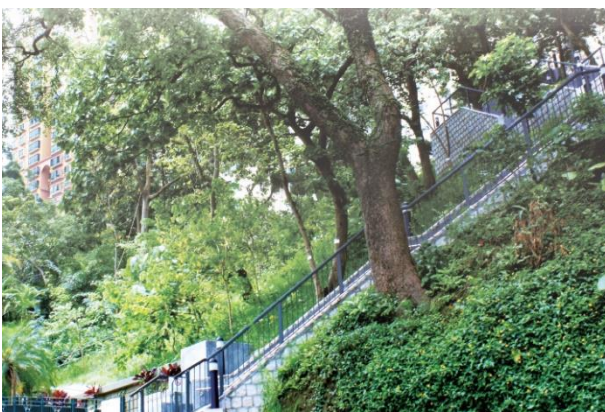
In exercising geotechnical control over private projects, we operate through the statutory powers of the Buildings Department to approve design submissions made by agents of the developers or private owners before construction proceeds.

The District Divisions also provide advice to Lands Department on the clearance of squatter structures on slope safety grounds.

One of the most effective methods for reducing landslide risks is land use planning, in which the potential impact of nearby natural hillside catchments and man-made slopes is taken into account in planning of new developments as part of a wider risk management strategy.

We provide the Planning Department and the Lands Department with geotechnical input at the early stages of land developments, advising on the suitability of land for specific purposes and any geotechnical constraints during development.

We also undertake technical studies to promote the enhanced use of rock caverns and urban underground space for more efficient use of land resources.



Vegetation on a man-made slope at Oaklands Avenue, Mid-level

## IMPLEMENTATION OF THE LANDSLIP PREVENTION AND MITIGATION PROGRAMME (LPMitP)

The GEO manages projects under the LPMitP, including planning and launching the projects, managing financial resources, monitoring works expenditure and progress, and appointing and managing consultants to undertake the projects. We select potentially substandard man-made slopes and vulnerable natural hillside catchments for inclusion into the LPMitP and provide technical support to other departments with regard to preventive maintenance works.

As part of the LPMitP, high priority man-made slopes, retaining walls and natural hillside catchments are studied to identify substandard slopes and vulnerable hillside catchments that require preventive and mitigation works. Where preventive, remedial or mitigation measures are needed for man-made slopes or natural hillside catchments that are under Government's maintenance responsibility, detailed design and the necessary works will be carried out to reduce the landslide risk.

In the design of slope upgrading works, innovative design approaches and new techniques are adopted where possible in order to improve quality and enhance cost effectiveness. We ride on the BIM platform to develop automated design processes for slope designs that enhance the efficiency and effectiveness of the design solutions. The automation technique is also shared amongst consultants undertaking LPMitP projects.



Digital design automation tool on BIM platform

We carry out tendering, management and supervision of contracts for LPMit works designed in-house.

Apart from in-house slope studies, we are also responsible for managing consultants, who are engaged in assignments to investigate, design, prepare contracts, manage and supervise the construction of LPMit works.

While our primary objective is to safeguard the public from slope failures, we have always given priority attention to blend in the engineering works with the surrounding environment by making them look as natural as possible. It aims to create a sustainable and biodiversified ecosystem that create habitats for wild lives, reduce susceptibility to pests and diseases, and allow natural plant succession. Every effort is therefore made to establish sustainable slope appearance and ecology and establish suitable vegetation around natural terrain hazard mitigation measures under the LPMitP. As a general rule, a hard surface cover is used only as emergency repairs to landslide scars and as a last resort on slope stability grounds. On average, we plant about 2.7 hundred thousand plants each year in connection with our landslip prevention and mitigation works, and most of the plants are native species.

As for slopes or retaining walls maintained by private owners, we engaged consultants to carry out safety screening study and recommend follow-up actions. Where there is prima facie evidence that the slope or retaining wall studied is dangerous or liable to become dangerous, statutory orders will be issued to the responsible private owners by the Buildings Department through the Buildings Ordinance to ensure appropriate follow-up actions to be taken on the sub-standard situations.

In 2021, about \$1.2 billion was spent on studies and LPMit works, through which 176 government man-made slopes were upgraded, safety-screening studies for 100 private man-made slopes were completed and mitigation works for 36 natural hillside catchments were implemented.

## NATURAL TERRAIN LANDSLIDE RISK MANAGEMENT

About 60% of Hong Kong's total land area consists of relatively steep natural terrain. Landslides occurring in natural terrain can be very large and travel long distances, such as those occurred in Tsing Shan in 1990, Sham Tseng San Tsuen in 1999, and western Lantau in 2008. The GEO has carried out numerous research and development activities since the early 1990s to prepare for the risks posed by natural terrain landslides. The natural terrain hazard studies and necessary mitigation works on selected sites with known significant natural terrain hazards are undertaken under the LPMitP.

Over the years, we have made significant advances in applying new digital and information technology to expand our ability to manage natural terrain landslides. Geographical Information System is used in spatial analysis of landslide data and 3-D engineering modelling of natural terrain. We have also capitalised on the advancement in remote sensing technologies to improve the quality of the datasets. For instance, the improved system used in the second territory-wide airborne Light Detection and Ranging (LiDAR) survey carried out in 2020 supported the generation of a higher quality digital terrain model for more detailed evaluation of landslide hazards in natural terrain landslide studies. Some of the other new technologies adopted include digital photogrammetry, satellite imageries, satellite-based Interferometric Synthetic Aperture Radar, and remote sensing techniques such as 3-D handheld laser scanning and image processing.



Tsing Shan debris flow in 1990

## LANDSLIDE INVESTIGATION

Systematic landslide studies are carried out as part of the LPMitP. The scope of landslide studies includes examination of all reported landslide incidents and in-depth studies of selected significant landslides to identify the causes of failure and necessary follow-up actions, and to undertake forensic assessments of landslides that involve subsequent coroner inquests or legal actions. The objectives of systematic landslide studies are to identify slopes in need of early attention and to review the performance of the Government's slope safety system to identify areas for improvement. Landslide studies will advance the understanding of the causes and mechanisms of landslides and enhance the slope engineering practices and the reliability of landslide preventive or mitigation works.



Investigation works under LPMitP

## STANDARDS AND TESTING

The GEO undertakes technical development work for the production of geotechnical standards. We promulgate technical guidance in our publications. Up to December 2022, we have released 450 publications. These can be purchased from the Publications Sales Unit of the Information Services Department, or downloaded from the CEDD website. Please refer to the catalogue of GEO publications on the CEDD website for details.

The technical development work is carried out in-house as well as in partnership with universities, consultants and contractors. It provides essential technical support to various aspects of the works for landslip mitigation. This includes development of design and construction approaches for landslide debris resisting barriers, technical guidelines on soil nail design and construction, development of prescriptive measures to improve existing man-made slopes and retaining walls, priority ranking system for the selection of slopes for actions, technical guidelines on landscape treatment for slopes and regional seismic microzonation study to assess seismic hazards of natural terrain.



Technical standards and guidance documents published by the GEO



Automated Steel Rebar Testing System



Automated Concrete Cube Testing System

Technical development work was also undertaken on quantitative risk assessment techniques for landslide risk management, assessment of debris mobility for natural terrain landslides, greening techniques, rainfall and landslide relationship, assessment of effects of climate change on landslide risk, and properties of saprolite, loose fill and other construction materials.

Testing services are provided through the Public Works Laboratories (PWL), which comprise the Public Works Central Laboratory and five Public Works Regional Laboratories. The PWL are accredited under the Hong Kong Laboratory Accreditation Scheme for most of the tests as well as a range of calibration services. The PWL provide a wide range of construction material testing services principally for government projects. These include tests on aggregates, bitumen and bituminous materials, cement, concrete, pulverised fuel ash, Ground Granulated Blastfurnace Slag, rubber, soil, rock, cement stabilised soil, steel, chemical compositions of construction materials and Time Domain Reflectometry tests on soil nails. In addition, the PWL conduct research and development work related to construction material testing to enhance the quality of service and meet the needs of the construction industry. We manage the List of Approved Suppliers of Materials and Specialist Contractors for Public Works under the category of Soil and Rock Testing. The PWL also provide testing services for other government departments on forensic investigations.



Triaxial Test of soil samples in PWL

## EMERGENCY SERVICES

There are around 300 reported landslides in Hong Kong each year. The GEO maintains a 24-hour year-round emergency service to provide geotechnical advice to government departments on emergency actions to be taken to deal with danger arising from landslides so as to protect public safety. Upon request, our geotechnical engineers will carry out site inspections with the responsible government departments and give advice on any necessary mitigation measures and emergency works.



The GEO Emergency Control Centre in operation

The GEO is responsible for operating and maintaining the Common Operation Picture (COP) to support relevant Government Departments for real-time sharing of emergency information brought by natural disasters (including flooding, landslides, structural incidents and major road blockages etc). The COP helps the Government in maintaining situation awareness and formulating contingency plans and measures.



Interactive map dashboard showing emergency information under the Common Operation Picture

## LANDSLIP WARNING SYSTEM

The GEO operates an automatic rain gauge system utilising advanced cloud and internet-of-things technologies. It comprises an extensive network of about 90 automatic rain gauges providing real-time rainfall data to the operation of the Landslip Warning System. Based on historical data, we developed a rainfall-landslide frequency model which can estimate the total number of potential landslides for a certain storm. By combining this with the rainfall forecasts from the Hong Kong Observatory, the Government is able to make a decision on the issuing or cancelling of a Landslip Warning.





Launching Ceremony for Commemorative Campaign on Remembrance and Reflection: 50 years after the Tragic Landslides on 18 June

## PUBLIC EDUCATION AND COMMUNITY ADVISORY SERVICES

The GEO has sustained community education programme to remind private owners of the importance of slope maintenance in preventing landslides, to promote public awareness towards landslide risks and to educate the public of the precautionary measures during heavy rain. Our dedicated Community Advisory Unit (Tel No.: 2760 5800) provides advice to private slope owners to discharge their slope maintenance responsibilities. During the epidemic of COVID-19, we held online seminars to educate private owners on the knowledge of slope maintenance.



GEO's online seminar on slope maintenance

Our public education activities include organising slope safety roving exhibitions and talks, broadcasting television and radio announcements of public interest, and promoting slope safety messages and enhancing public preparedness towards landslide disasters through media, electronic platforms, social media, etc.



A geotechnical engineer provided advice on slope safety and related maintenance issues during an exhibition

The Po Shan Drainage Tunnel is one of the most iconic Landslip Prevention and Mitigation Works in Hong Kong. It was specially designed and constructed to reduce the risk of landslides at Po Shan hillside by effectively regulating the groundwater level. Given the uniqueness of the Po Shan Drainage Tunnel and its novel features, we established a “Landslide Sci-Tech Chamber” in the tunnel to convey the importance of slope safety to the public by guided tours.



Guided Tour for Po Shan Drainage Tunnel - Landslide Sci-Tech Chamber

We also conduct the “School Ambassador Programme” (SAP) to enhance students’ awareness on landslide hazard and other natural disasters through exhibitions, seminars and STEM workshops within the framework of the senior secondary geography curriculum. Virtual tours, including the SAP and exhibitions, are available in the Hong Kong Slope Safety website.

We regularly organise seminars and visits for geography teachers. We also work with non-governmental organisations to reach out to local communities for promulgating slope safety messages.



School Ambassador Programme

## SLOPE INFORMATION SYSTEM

Landslide prevention begins with information. The GEO's work in improving slope safety in Hong Kong is greatly enhanced by the use of information technology to collect and disseminate slope information. Containing information of 60 000 registered man-made slopes and retaining walls, the Slope Information System (SIS) provides engineers as well as the general public with updated slope information through the slope safety website (<http://hkss.cedd.gov.hk>). Information in the SIS needs to be updated whenever the existing slopes are modified or new slopes are formed. We launch the online Slope Registration System to facilitate consultants and engineers in providing up-to-date information pertinent to the slopes and mitigation measures. In line with the Government Open Data Policy, the GEO releases suitable spatial data in the public domain to facilitate research and development in technological innovation. The open data is available in Government data portal (<https://data.gov.hk>), as well as GEO's data portal (<https://www.ginfo.cedd.gov.hk/geopendata>).

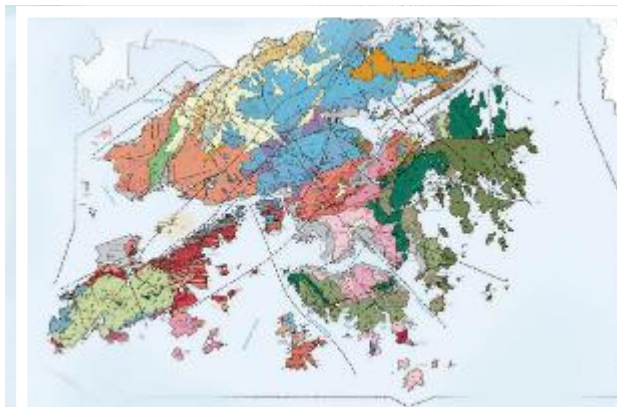


Hong Kong Slope Safety website

## HONG KONG GEOLOGICAL SURVEY

One of the GEO's most notable technical achievements is the development of improved understanding of the characteristics of weathered rock, which is prerequisite for a successful slope engineering design. Many of the landslide problems that affect Hong Kong are related to weathering processes which gradually change rock into soil.

In 1982, we established the Hong Kong Geological Survey. It maintains the most comprehensive archive of geological information in Hong Kong and provides authoritative advice on Hong Kong's geology to the Government, the engineering profession and the public. It also produces geological maps and relevant publications, and compiles engineering geological and natural terrain database for use by the Government and the private sector. Many of the datasets are stored in the Geographical Information System. An online version of the geological map of Hong Kong has been uploaded onto the slope safety website which is accessible via <http://hkss.cedd.gov.hk>. A mobile version of the geological map of Hong Kong can also be downloaded from the Android Play Store and Apple App Store.



Geological map of Hong Kong

## ADVISORY AND GROUND INVESTIGATION SERVICES

The GEO undertakes geotechnical feasibility studies, investigations and design for a wide range of government projects. We also provide ad-hoc 'clinic' advice to project departments to deal with geotechnical problems regarding natural terrains, caverns and tunnels during the project implementation. In addition, we render project-based support for works departments to enhance the cost-effectiveness of geotechnical works in major capital works projects.



Kau Shat Wan Government Explosives Depot, Lantau

Furthermore, we implement tunnel / cavern related projects in order to develop underground space for government uses

and free up land for better urban developments. Furthermore, we manage the list of accepted reinforced fill products used in Hong Kong and the list of approved off-site steel rebar prefabrication yards for government contracts.

Through the engagement of term contracts, we provide ground investigation services and geophysical surveys to government departments. We also manage the List of Approved Suppliers of Materials and Specialist Contractors for Public Works under the category of Ground Investigation Field Work.

## REGULATORY CONTROL OF EXPLOSIVES AND MANAGEMENT OF QUARRIES

Mines Division, on behalf of the Commissioner of Mines, who is the Director of Civil Engineering and Development, is the regulatory authority for the manufacture, storage, conveyance (on land) and use of explosives under the Dangerous Goods Ordinance. It is also responsible for issuing Mines Blasting Certificates under the Mines (Safety) Regulations to shot firers who are permitted to use blasting explosives. As part of its responsibilities, the division manages the Government Explosives Depots, which provide storage for explosives, provides an explosives delivery service from the Depots to blasting sites, carries out audit inspections for blasting sites and explosives stores, and provides technical support to other government departments on matters relating to explosives, including fireworks displays.

Mines Division is responsible for the management and rehabilitation of quarries in Hong Kong. These quarries supply aggregates and rock products to the local construction industry. They also process surplus rock generated from local construction projects to produce aggregates and other rock products. As an on-going exercise, the division carries out studies related to strategy of rock supply and Hong Kong's rock resources management, including searching for potential quarry sites, research on aggregate suitability and review on supply chain of concrete.



Government explosives delivery trucks and vessels

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