

## **SLOPE SAFETY IN HONG KONG**

### **KEY POINTS**

1. The Government's objective and vision on landslide risk management is to meet Hong Kong's needs for the highest standards of slope safety. To achieve this objective and vision, a comprehensive Slope Safety System has been formulated under the policy direction of the Development Bureau. The Slope Safety System is managed by the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD), with the overall target of minimizing landslide risk to the whole community. The key strategies in reducing the landslide risk include:

- I Minimizing risk arising from new developments**
- II Implementation of landslip prevention and mitigation measures to systematically contain the overall landslide risks of the existing man-made slopes and natural hillside catchments**
- III Reducing risk by minimizing the possible consequences of landslides**

2. Hong Kong has a history of tragic landslides. In the past 60 some years after 1947, more than 470 people died in landslide incidents, mostly as a result of failures associated with man-made cut slopes, fill slopes and retaining walls. Newspaper records of landslide fatalities and other impacts on the community go back much earlier to the 19th century. Even today, although the risk to the community has been greatly reduced by concerted Government action since 1977, on average about 300 incidents involving failure of man-made slopes, retaining walls and natural hillsides are reported to the Government each year. Many of these incidents are minor, just washouts and erosion on the surfaces of slopes and hillsides, but a significant proportion are larger failures which can threaten life and property, block roads and disrupt the community.

3. Since the establishment of the GEO in 1977, the Government has achieved a lot in enhancing slope safety. Our Slope Safety System is highly regarded by geotechnical practitioners and natural hazard managers worldwide. We have:

- catalogued some 60,000 sizeable man-made slopes and mitigation measures on natural hillsides in Hong Kong, and have carried out a preliminary field inspection of all of them. The Catalogue of Slopes and the technical information it contains are available on the Internet in both the Chinese and English languages;
- identified the maintenance responsibility of all the catalogued slopes, and have made this information available to the public;
- published geotechnical standards which are extensively referred to and well respected internationally; and
- set up an extensive network of automatically recording raingauges throughout Hong Kong to provide real time rainfall data for the issue of public Landslip Warnings.

4. Other measures to achieve landslide risk reduction include the following:

- operation of a 24-hour year-round emergency service by providing advice to Government departments on immediate or potential danger due to landslide incidents, and on measures to deal with them;
- investigation of serious landslides to continuously improve our knowledge and standards;
- auditing the design and supervision of construction of all new slopes to ensure that they meet the required safety standards;
- a rolling Landslip Prevention and Mitigation Programme (LPMitP) to systematically deal with the landslide risks associated with man-made slopes and natural hillside catchments;
- a total expenditure of about HK\$900 million each year by the maintenance departments to properly maintain all government man-made slopes and all mitigation measures on natural hillsides;
- taking steps to ensure that private owners take responsibility for their own slopes through sustained public education and assistance, through safety-screening by the GEO, and through the issue of statutory orders by the Building Authority requiring investigation and rectification;

- undertaking extensive public education on personal safety precautions in order that the community can be better informed on how to protect themselves during periods of intense rainfall; and
- an ongoing programme to assess squatter villages for clearance of squatter huts on slope safety grounds, and to provide guidance to the residents of squatter huts on landslide risk and protection of their own safety.

5. In addition to enhancing the stability of slopes, we also strive to make them look as natural as possible and blend them with the surroundings. Technical guidelines have been issued on good practice in landscape treatment and bio-engineering for slope works. All newly constructed and upgraded government slopes are landscaped, and the use of hard surfacing in slope works is minimized and critically vetted. Private slope owners are encouraged to follow the same standards. A layman's guide to landscape treatment of slopes is available free of charge to assist the general public.

6. Since May 1995, a Slope Safety Technical Review Board (SSTRB) has been appointed to advise the Government on technical aspects of slope safety. The Board Members have been selected based on their high international standing in the geotechnical engineering profession, possession of appropriate knowledge and experience related to slope safety, and no involvement in commercial projects in Hong Kong. Our Slope Safety System is reviewed regularly and benchmarked internationally through the SSTRB.

7. The effectiveness of the Slope Safety System is indicated by the declining casualty rate, which shows that landslide danger in Hong Kong has been substantially reduced since 1977. This is confirmed by predictive risk assessment calculations. The overall landslide risk level arising from old substandard man-made slopes has been reduced to less than 25% of the overall risk level in 1977. However, there is no room for complacency. Because of Hong Kong's physical setting and history of development, the landslide risk can never be completely eliminated, and our slope safety problems cannot be solved by government actions alone. We need to continue to work in partnership with the whole community, i.e. Government deals with government slopes and private owners deal with private slopes and the general public take the necessary personal precautionary measures to protect themselves and their families from landslide risks during periods of heavy rainfall. In addition, from 2010 onward, landslide prevention and mitigation measures are implemented to contain the landslide risk arising from vulnerable hillside catchments affecting developments and major transport corridors. The Government will continue to provide assistance through public education, and public information and community advisory services.

## **BACKGROUND**

8. Hong Kong's steeply hilly terrain, heavy rain and dense development make us prone to risk from landslides. We have a high rainfall, with an annual average of 2,300 mm which falls mostly in the summer months between May and September, and high rainfall intensities. Hong Kong's total land area is only about 1,100 square kilometres, and we have a severe land shortage. Despite this, we have had a steady and rapid population growth since the end of World War II, and major economic expansion. Between 1948 and 1977, our population increased from 1.8 million to 4.6 million. During this period, and earlier, there was no fully effective system in place to control the geotechnical standards of land development. Many new immigrants, having nowhere to live, built flimsy squatter huts on steep hillsides, and worsened their already precarious situation with uncontrolled cutting and filling. In the 1950s and 1960s, the Government did its best to build resettlement estates for the immigrants. Unfortunately, some of the earthworks of those days were not of a design and construction sufficiently robust to cope with severe rainstorms.

9. The result was frequent failures of man-made slopes, culminating in 1972 in two major disasters on the same day. On 18 June 1972 in Sau Mau Ping Estate in Kowloon, a 40m high road embankment collapsed, killing 71 people. This was followed a few hours later by the collapse of the hillside above a steep temporary excavation on Conduit Road in the Mid-Levels area of Hong Kong Island which triggered a landslide that demolished a 12-storey residential building and killed 67 people.

10. Four years later, another severe rainstorm hit Hong Kong and brought down three fill slopes in Sau Mau Ping Estate again which were constructed without proper compaction. The resulting landslides killed 18 people. The then Governor Sir Murray MacLehose immediately appointed an independent review panel of international experts to study the problem and recommend a solution. The panel recommended the establishment of a control organization to regulate hillside development and the design, construction and maintenance of slopes. This led to the formation of a Government geotechnical control body, the former Geotechnical Control Office (now the GEO), in 1977.

11. The GEO currently has a professional staff establishment of about 210 specialist engineers and scientists, who are supported by approximately 310 technical grade staff members in geotechnical, civil, chemical, explosives, quarrying, laboratory, cartographic and works supervisory streams. In total, the GEO has a staff establishment of about 640 for its wide range of geotechnical and civil engineering activities.

12. The establishment of a comprehensive Slope Safety System has played an important role in the prevention of landslide disasters. An integral part of the system is the concept of continuous improvement in service to the community, so that the GEO will continue to strive for the highest possible safety standards. The key strategies in reducing the landslide risk in Hong Kong include:

## **I. Minimizing risk arising from new developments**

- auditing the design and supervision of construction of new slopes;
- providing input to land use planning.

## **II. Implementation of landslip prevention and mitigation measures to systematically contain the overall landslide risks of the existing man-made slopes and natural hillside catchments**

- implementation of the Landslip Prevention and Mitigation Programme (LPMitP) to systematically deal with the landslide risks associated with the man-made slopes and natural terrain catchments;
- improving the stability of government man-made slopes not covered by the LPMitP under the preventive maintenance programme by the slope maintenance departments;
- maintaining all registered government man-made slopes and mitigation measures on natural hillsides by:
  - updating, maintaining and releasing the Catalogue of Slopes which contains information of some 60,000 sizeable man-made slopes and mitigation measures on natural hillsides;
  - updating, maintaining and releasing the register of maintenance responsibility of man-made slopes and mitigation measures on natural hillsides;
  - periodic inspection and routine maintenance of all government man-made slopes and mitigation measures on natural hillsides; and
  - systematic inspection and repair of all government underground drains and water pipes which may affect the stability of adjacent slopes.
- ensuring that private owners take responsibility for slope safety by:
  - promoting public awareness and response in slope safety through public education, publicity, information services and public warnings;
  - safety-screening of old private man-made slopes and enforcing statutory action to require owners to investigate and carry out necessary upgrading works to substandard slopes;

- initiating and enforcing statutory action to require owners to repair underground drains and water pipes which may affect the stability of adjacent slopes.

### **III. Reducing risk by minimizing the possible consequences of landslides**

- identifying squatter huts at high risk from landslides so that clearance actions can be taken;
- promoting public awareness and response in slope safety through public education, publicity, information services and public warnings such as:
  - organizing public education campaigns, e.g. roving exhibitions and school talks on slope safety;
  - operation of the Landslip Warning System;
  - maintaining a 24-hour year-round emergency service by providing advice to Government departments on immediate or potential danger due to landslide incidents, and on measures to deal with them; and
  - providing information and community advisory services.

13. In addition, the GEO has been putting tremendous effort in technical development work, with a view to improving the slope safety standards, technology, and administrative and regulatory frameworks. Geotechnical research projects have been undertaken, which resulted in the promulgation of slope safety standards and professional guidance documents. It also enhanced our geotechnical control strategy on building and infrastructure developments. Furthermore, investigations into the causes of significant and serious landslides have been undertaken for forensic purposes and with a view to continuously improve the Slope Safety System.

14. To dovetail with the Landslip Preventive Measures Programme completed in 2010, the Government has launched the LPMitP to contain the overall landslide risk associated with man-made slopes and natural hillside catchments at a level within the As Low as Reasonably Practicable (ALARP) zone.

#### **Further information**

15. Further information about the Slope Safety System can be obtained by writing to the Head of the Geotechnical Engineering Office at the address below.

## **SUBJECT OFFICER AND TELEPHONE NUMBER**

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