

## Management of Natural Terrain Landslide Risk

**Key Messages:** Government's strategy is to keep the natural terrain landslide risk to a level that is as low as practically achievable. Study and mitigation of natural terrain hazards affecting existing developments are carried out following the 'react-to-known-hazard' principle. Undue increase in the risk to new developments is controlled through avoidance of development in hazardous areas as far as possible, and study and mitigation of hazards as part of new developments where required.

### Natural Terrain Landslides in Hong Kong

Natural terrain landslides include slope failures and boulder falls from natural hillsides that are not significantly modified by human activities. These natural hillsides cover over 60% of the land area of Hong Kong, and landslides occur on them as part of the processes of erosion and landform evolution. As with other landslides, the location and timing of landslides on natural hillsides cannot be predicted precisely.

Some relevant statistics are as follows:

- From a review of high-level aerial photographs taken between 1945 and 2000, about 30,000 past landslides on natural terrain were identified, of which about 19,000 occurred within this period. On average over the period of 1945 to 2000, about one natural terrain landslide occurs each year for every two km<sup>2</sup> of the natural hillsides of Hong Kong.
- Most of the natural terrain landslides occur in relatively remote areas but some of them affect existing developments. Between 1982 and 2003, about 1000 natural terrain landslides affecting developed areas were reported to the GEO. Most of these landslides were small-scale slope failures affecting open spaces, minor roads and footpaths, and other less important facilities.
- In the past 20 years, failures of 'undisturbed' natural slopes had not resulted in any fatality in planned developments, i.e. excluding squatter areas. However, boulder fall from natural terrain had resulted in one fatality and failure of predominantly natural hillside had led to two fatalities in planned developments (GEO, 1996). Over the same period, 18 fatalities were caused by failures of man-made slopes affecting planned developments.

- A significant number of fatalities are also known to have occurred in squatter areas as a result of landslides. Current Government policy is to deal with such unplanned developments by clearance of squatters (see Note below).

The historical natural terrain landslide data give an indication of the scale of the problem, and they show that the landslide risk from natural hillsides is lower than that from man-made slopes in Hong Kong. However, the data may not fully reflect the inherent landslide risk to the community. Some landslides were 'near-miss' incidents that could well have resulted in more serious consequences. This situation will be aggravated as more new developments take place on, or close to, steep natural hillsides.

### **Management of Natural Terrain Landslide Risk**

The Government's Slope Safety System has focused more attention on landslide risk from man-made slopes, as this hazard posed a greater global risk to the community than from natural terrain hazards. While the Government is reducing the risk from man-made slopes, the risk from natural hillsides could increase as the population of Hong Kong grows and new developments encroach on steep natural hillsides.

The Government's strategy for management of natural terrain landslide risk aims at keeping the natural terrain landslide risk to a level that is as low as practically achievable.

The Government adopts a 'react-to-known-hazard' principle in dealing with natural terrain hazards affecting existing developments, i.e. to carry out studies and mitigation actions where significant hazards become evident. This strategy is modelled on that for dealing with boulder fall hazards from natural terrain (see Appendix A), which has been implemented for more than 10 years.

For new developments, the Government aims to contain undue increase in natural terrain landslide risk. This is implemented through judicious land-use and project planning to avoid development in hazardous areas (see Appendix B), and requirement for study and mitigation of natural terrain hazards as part of new developments in close proximity to natural hillsides. The GEO uses a set of criteria to determine where the natural terrain hazards would require further studies (see Appendix C).

### **Technical Approach for Dealing with Natural Terrain Hazards**

Since 1994, the GEO has been carrying out systematic research and development on natural terrain hazards in Hong Kong. An inventory of landslides (the Natural Terrain Landslide Inventory) has been compiled, and is available for public viewing in the Civil Engineering Library and on the Hong Kong Slope Safety Website (<http://hkss.cedd.gov.hk>).

Note: Since the mid-1980s, the GEO has been undertaking a programme to recommend safety clearance of squatter structures that are identified as being especially vulnerable to landslide risk, based on geotechnical studies and inspections. The programme has proved to be effective in reducing the number of landslide fatalities in squatter areas, from 27 fatalities in the 1980s to two fatalities in the 1990s.

The GEO has published the following technical guidance documents for use by the profession in study and mitigation of natural terrain hazards:

- Special Project Report No.1/2002, which provides guidelines on study of natural terrain hazards
- GEO Report No. 104, which provides guidelines on design of debris-resisting barriers
- GEO Report No. 75 (Landslides and Boulder Falls from Natural Terrain : Interim Risk Guidelines (1998)), which provides guidelines on acceptable/tolerable risk levels

The Government's strongly preferred technical approach is not to carry out stabilization works to large areas of natural terrain, which would be both impractical and environmentally damaging, but to mitigate the risk through adjustments to the layout of new developments and provision of buffer zones and defense measures (e.g. debris-resisting barriers).

Natural hillsides do not require maintenance. Where hazard mitigation measures are provided to a natural hillside, it is only necessary to maintain the physical integrity and continued functionality of the measures. The recommended good practice for maintenance of natural terrain hazard mitigation measures is provided in Geoguide 5 (Third Edition) – Guide to Slope Maintenance.

#### **Reference**

GEO (1996) Report on the Shum Wan Road Landslide of 13 August 1995 – Volume 2, Findings of the Landslide Investigation, Geotechnical Engineering Office, Civil Engineering Department, 51p.

**Prepared by Planning Division  
Geotechnical Engineering Office  
Civil Engineering and Development Department  
July 2004**

**Government's Boulder Policy**

- (i) Boulders affecting existing developments:
  - (a) Urgent preventative action shall be taken where there is an immediate and obvious danger.
  - (b) Evaluations of boulder stability shall be undertaken only where there have been persistent boulder falls or where there is reason to believe that a dangerous situation could develop. Preventative action shall be taken when considered necessary.
- (ii) Boulders affecting proposed developments:
  - (a) Preventative action shall be taken where there is an immediate and obvious danger to the proposed development.
  - (b) Evaluations of boulder stability shall be undertaken only where there would be a significant risk. Preventative action shall be taken when considered necessary.

## Appendix B

### **The following is extracted from the Geotechnical Manual for Slopes (1984 edition):**

“Natural slopes are frequently close to limiting equilibrium over very large areas, and preventive work can be expensive and difficult. It is clearly not advisable to undertake extensive trimming-back of natural slopes in order to achieve what may only be marginal improvement in stability. In such cases, disturbance of natural slopes and vegetation and the need for costly preventive or protective measures may be avoided by siting structures away from areas that could be affected by landslide debris.

Natural slopes need not meet the factors of safety (for new man-made slopes) provided that:

- (a) the slope is undisturbed (e.g. has not been and will not be cut, stripped of vegetation, subjected to increased loading or subjected to increased infiltration by alteration of the natural drainage regime), and
- (b) a careful examination is made to determine that there is no evidence of instability or severe surface erosion.

In assessing natural slopes, consideration should always be given to the possible presence of potentially unstable boulders.”

**Criteria Used by GEO for Assessing  
Whether a New Development Requires  
Study of Natural Terrain Hazards**

For new developments involving occupied buildings, major infrastructure facilities, busy roads, densely-used open areas, etc., natural terrain landslide hazards need to be studied:

Where there is natural terrain outside the site, but within the same catchment, which is at an angular elevation of  $20^{\circ}$  or more from the site, and where there is natural terrain sloping at more than  $15^{\circ}$  within 50 m horizontally upslope of the site, provided that there is a credible flowpath to the site.

There are occasionally cases where a natural terrain landslide hazard study may also be required for development sites which do not meet the above criteria, as for example for development sites which are either intersected by or adjacent to a natural drainage course.