

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 landslide hazards affecting existing developments are systematically carried out under the Landslip Prevention and Mitigation Programme, 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 locations and timing of landslides on natural hillsides cannot be predicted precisely.

Some relevant statistics are as follows:

- From a review of both high- and low-level aerial photographs taken between 1924 and 2006, about 105,000 past landslides on natural terrain were identified.
- Most of the natural terrain landslides occur in relatively remote areas but some of them affect existing developments. Between 1982 and 2006, about 1,100 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.
- Since 1980, natural terrain landslides and boulder falls have caused three fatalities in developed areas (i.e. excluding squatter areas) and thirteen fatalities in squatter areas (see Note below¹).

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

¹ 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.

have resulted in more serious consequences. This situation will be aggravated as more new developments take place on, or close to, steep natural hillsides.

The severe rainstorm of 7 June 2008 highlights the potential vulnerability of developments located close to natural terrain. This rainstorm caused several hundred landslides, including many debris flows that affected developed areas. The significant scale of these natural terrain landslides appears to be related to the severity of the rainfall, which reached a maximum of 380 mm in a 4-hour period, with an estimated Landslide Potential Index of 12.3 and a theoretical statistical return period of 1100 years. Importantly, the intense rainfall was concentrated in areas of steep natural hillsides.

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The Landslip Preventive Measures Programme has so far focused mainly on dealing with 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 is on the rise 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. It entails the following general principles :

- (a) 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. Under the post-2010 Landslip Prevention and Mitigation Programme (LPMitP, see IN 05/2008), about 30 natural terrain catchments with known hazards to existing buildings and important transport corridors will be systematically dealt with annually, pursuant to the 'react-to-known-hazard' approach.
- (b) 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 A), 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 B).

Technical Approach for Dealing with Natural Terrain Landslide Hazards

Since 1994, the GEO has been carrying out systematic research and development on natural terrain landslide hazards in Hong Kong. An inventory of landslides (the Enhanced Natural Terrain Landslide Inventory) has been compiled from a review of high- and low-level aerial photographs from 1924 to 2003. It is available for public viewing in the

Civil Engineering Library and on the Hong Kong Slope Safety Website (<http://hkss.cedd.gov.hk>).

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

- GEO Report No. 75, which provides guidelines on acceptable/tolerable risk levels
- GEO Report No. 104, which provides guidelines on design of debris-resisting barriers
- GEO Report No. 138, which provides guidelines on study of natural terrain hazards

The Government's strongly preferred 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.

Reference

ERM-Hong Kong, Ltd (1998). GEO Report No. 75. Landslides and Boulder Falls from Natural Terrain : Interim Risk Guidelines. Geotechnical Engineering Office, Civil Engineering and Development Department, 183 p.

GEO (2003). Geoguide 5. Guide to Slope Maintenance (3rd Edition). Geotechnical Engineering Office, Civil Engineering Department, 132p.

Lo, D.O.K. (2000). GEO Report No. 104. Review of Natural Terrain Landslide Debris-resisting Barrier Design. Geotechnical Engineering Office, Civil Engineering Department, 91 p.

Ng, K.C., Parry, S., King, J.P, Franks, C.A.M. and Shaw R. (2003). GEO Report No. 138. Guidelines for Natural Terrain Hazard Studies. Geotechnical Engineering Office, Civil Engineering Department, 138 p.

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July 2008**

Appendix A

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.”

Appendix B

Criteria Used by GEO for Determining the Need for Natural Terrain Hazard Study for New Development

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

“Where there is natural terrain outside the site, but within the same catchment, which is at an angular elevation of 20° or more from the site, and where there is natural terrain sloping at more than 15° 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, for example for development sites which are either intersected by or adjacent to a natural drainage course.