

EXECUTIVE SUMMARY

The Geotechnical Engineering Office (GEO) had commissioned ERM to develop risk guidelines for landslides and boulder falls from natural terrain in Hong Kong. Given the demand for additional housing accommodation in the coming years, there may be increasing pressure to develop areas close to steep natural terrain. The objective of this study is therefore to develop a risk guidelines which can then be adopted to examine if developments close to or within the natural terrain can be permitted.

The approach for developing risk guidelines for landslides and boulder falls follow the steps described below:

Review

A review of the approaches adopted overseas in the development of risk criteria was carried out. This review included mainly criteria for major hazard installations handling dangerous chemicals in countries such as UK, the Netherlands, Australia, France and Switzerland. Criteria adopted by rail operators in UK and criteria adopted for civil engineering projects such as large dams (by BC Hydro and ANCOLD) were also examined.

A review of the risk guidelines adopted in Hong Kong for Potentially Hazardous Installations (PHI) handling dangerous chemicals was carried out. In addition criteria adopted for dangerous goods transportation and those adopted by local rail operators were also covered.

A review of the recent QRA studies on landslides and boulder falls in Hong Kong was carried out to examine the risk levels estimated by these studies and the approaches adopted for comparing the results with say existing PHI criteria.

A review of natural hazards worldwide was carried out to examine the frequency of such events and the fatalities caused to compare with man-made events. The natural hazards covered include earthquakes; tsunamis, windstorms, floods, volcanic eruptions etc.

Conclusions from the Review

The conclusions from the above review can be summarised as follows:

- all of the countries reviewed have specified acceptability criteria for major hazard installations. Such criteria are either risk based or consequence based although both the approaches acknowledge the requirement of a minimum separation distance between a major hazard facility and the surrounding population;
- there are no established criteria backed by a Government for landsliding although various criteria have been evolved and adopted for example in projects such as dams;
- the public may tolerate a relatively high risk from natural landslide hazards. However, the distinction between man-made and natural hazards is not a rigorous one. For landslides from natural terrain affecting a new development, the public may perceive a strong element of human

involvement since the development was allowed to be permitted by Government in the first place. Therefore, while the hazard may be regarded as an outcome of a natural phenomenon, the risks imposed on the population are outcome of decisions made by men.

It was therefore concluded to develop criteria similar to the existing PHI criteria for Hong Kong which relate to man-made hazards.

Proposed Criteria for Individual Risk (IR)

As regards risk guidelines for Individual Risk, the study recommends adoption of the existing criteria for PHIs.

The maximum allowable Individual Risk level to a member of the public in a new development from any natural terrain landslides and boulder falls should not exceed 10^{-5} per year.

For existing developments it is proposed that the maximum individual risk to which any member of the public should be exposed from natural terrain landslides and boulder falls is taken to be 10^{-4} per year.

It is also recommended that the maximum IR criteria of 10^{-5} per year for new developments, and 10^{-4} for existing developments should also be applied to the most vulnerable population. The risk calculations should therefore take account of the higher vulnerability of such persons, and the criteria is therefore more stringent (if such vulnerable persons are present) than the current PHI risk guidelines.

Proposed Criteria for Societal Risk

The study considered various options to evolve criteria for societal risk and has recommended that the preferred option is to use the existing PHI societal risk criteria as a direct basis for the development of criteria for landslides and boulder falls from natural terrain. However, some changes have been proposed:

There should be no "acceptable" line on the F-N curve, and the principle of ALARP (As Low As Reasonably Practicable) should be applied for all risks which fall below the "unacceptable" line. This is consistent with the recent approaches for example in the Netherlands where the lower 'acceptable' line has been eliminated.

The limit of tolerability for the number of fatalities (from a single event) should be extended from the 1000 fatalities used for PHI sites to 5,000 fatalities. A vertical line should be drawn on the F-N graph at 1000 fatalities (up to the -1 slope 'unacceptable' line), and fatalities in the region 1000-5,000 (up to the -1 slope 'unacceptable' line) should be treated as an 'Intense Scrutiny' region.

It is strongly recommended, however, that the societal risk criteria should not be mandatory, and should be used as guidelines only.

The recommended societal risk guideline is shown in Figure 7.4a. An alternate option for the societal risk guidelines is shown in Figures 7.4b for further discussion. The alternate option is similar to the current guidelines for a PHI, except that the criteria include an 'intense scrutiny' region for fatalities in the 1000-5000 region.

The reason for including an 'intense scrutiny' region in the risk guidelines is to provide an option to regulators to permit certain types of developments. Such developments may not necessarily be unacceptable but would be examined with special scrutiny considering the social needs.

Application of the Criteria

In order to apply the criteria, it is necessary to define the area of natural terrain that must be considered. The study proposes an approach whereby a 500m length of natural terrain (which presents risk to the community) should be considered as the basis for the QRA. The study proposes a Consultation Zone which extends about 150m from the toe of the slope but includes the slopes themselves up to the summit. Any development with a significant population increase within the Consultation Zone should require a QRA study.

The study also provides an approach for Cost Benefit Analysis (CBA) which must be carried out to demonstrate ALARP, a requirement under the proposed criteria. A 'value of life' figure of HK\$24 million adjusted suitably for inflation may be adopted.

An approach for consideration of aversion factors for multiple deaths is proposed whereby an aversion factor of greater than one may be considered for 'high risk' situations, ie when the F-N curve is within one order of magnitude to the 'unacceptable' or 'intense scrutiny' region. It is also suggested to apply a higher aversion factor of up to 20 for FN curves within the 'intense scrutiny' region.

The proposed criteria should be regarded as a starting point for extensive consultation on the subject. Further work may be required to assess public perception and expectation, the practicality of adopting the criteria including cost-benefit implications etc.