Review of Alert Criteria In Respect of Natural Terrain Hazards

GEO Report No. 337

F.W.Y. Ko

Geotechnical Engineering Office
Civil Engineering and Development Department
The Government of the Hong Kong
Special Administrative Region

Review of Alert Criteria In Respect of Natural Terrain Hazards

GEO Report No. 337

F.W.Y. Ko

This report was originally produced in November 2013 as GEO Technical Note No. TN 5/2013

First published, April 2018

Prepared by:

Geotechnical Engineering Office,
Civil Engineering and Development Department,
Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon,
Hong Kong.

Preface

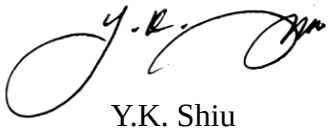
In keeping with our policy of releasing information which may be of general interest to the geotechnical profession and the public, we make available selected internal reports in a series of publications termed the GEO Report series. The GEO Reports can be downloaded from the website of the Civil Engineering and Development Department (http://www.cedd.gov.hk) on the Internet.

W.K. Pun
Head, Geotechnical Engineering Office
April 2018

Foreword

This study reviews the Alert Criteria in respect of natural terrain hazards as stipulated in GEO Report No. 138 with due regard to the latest landslide data. The review examines the travel angles, toe slope angles and runout distances beyond ≤ 15° ground slope of all recent landslides in the Enhanced Natural Terrain Landslide Inventory, and makes recommendations on possible improvements.

The review was carried out by Ms Florence W.Y. Ko under the supervision of Mr K.K.S. Ho and Mr Y.K. Shiu. Mr W.K. Ho provided technical support to the analyses of landslide data using GIS technology. All contributions are gratefully acknowledged.



Y.K. Shiu
Chief Geotechnical Engineer/Standards & Testing

Abstract

This study reviews the Alert Criteria in respect of natural terrain hazards as stipulated in GEO Report No. 138 with due regard to the latest landslide data. The review examines the travel angles, toe slope angles and runout distances beyond $\leq 15°$ ground slope of all recent landslides in the Enhanced Natural Terrain Landslide Inventory (ENTLI), and makes recommendations on possible improvements.

The Alert Criteria have been reviewed using the most up-to-date landslide data in the ENTLI and the 1:1000-scale topographic maps, together with the latest Geographic Information System technology. The resolution and accuracy of the measurements of the travel angles, toe slope angles and runout distances beyond $\leq 15°$ ground slope are greatly enhanced. As a result, the findings of the review are more reliable and representative.

The findings of the review indicate only minor variations (about 1%) in the cumulative percentages of natural terrain landslides covered by the two criteria under the Alert Criteria, as compared to the previous study. Change to the Alert Criteria is considered not necessary at this stage.

Contents

List of Tables

List of Figures

1 Introduction

This study reviews the Alert Criteria in respect of natural terrain hazards as stipulated in GEO Report No. 138 (Ng et al, 2003) with due regard to the latest landslide data. The review examines the travel angles, toe slope angles and runout distances beyond ≤ 15° ground slope of all recent landslides in the Enhanced Natural Terrain Landslide Inventory (ENTLI), and makes recommendations on possible improvements.

The study follows largely the same methodology adopted previously for developing the Alert Criteria (Choi et al, 2003), with updates on the sources of landslide and topographic data and the use of the latest Geographic Information System (GIS) technology.

2 Alert Criteria

For a site that may be affected by natural terrain hazards but does not satisfy the In-principle Objection Criteria, a natural terrain hazard study (NTHS) is required to assess the hazards and identify the necessary risk mitigation measures. The Alert Criteria (Figure 2.1) (Ng et al, 2003) are used as a guide to decide whether a site would fall under this category, and they include the following criteria:

(a) It is a new development site involving provision of Group 1 to 3 facilities, or it is a redevelopment that requires modification of the lease conditions and involves either a significant population at risk or a significant increase in population at risk; and

(b) Where there is natural terrain outside the site, but within the same catchment, that is at an angular elevation of 20° or more from the site and where there is ground sloping at more than 15° within 50 m horizontally upslope of the site, provided that there is a credible debris flowpath to the site.

According to Ng et al (2003), the Alert Criteria should be applied with due consideration of the following supplementary guidance:

(a) An NTHS may be required for sites that lie beyond the area delineated by the above criteria, for example for sites where there are historical landslides with long debris run-out extending beyond these limits, and for sites that are either intersected by, or adjacent to, natural drainage course;

(b) A “credible debris flowpath” is generally a downhill path followed by surface water. However, flowpaths that debris could follow but are deemed unlikely to do so would not be regarded as “credible”. For example, a debris flow path down a ridge line, rather than descending into the catchment on either side of the ridge line, would not be “credible”.

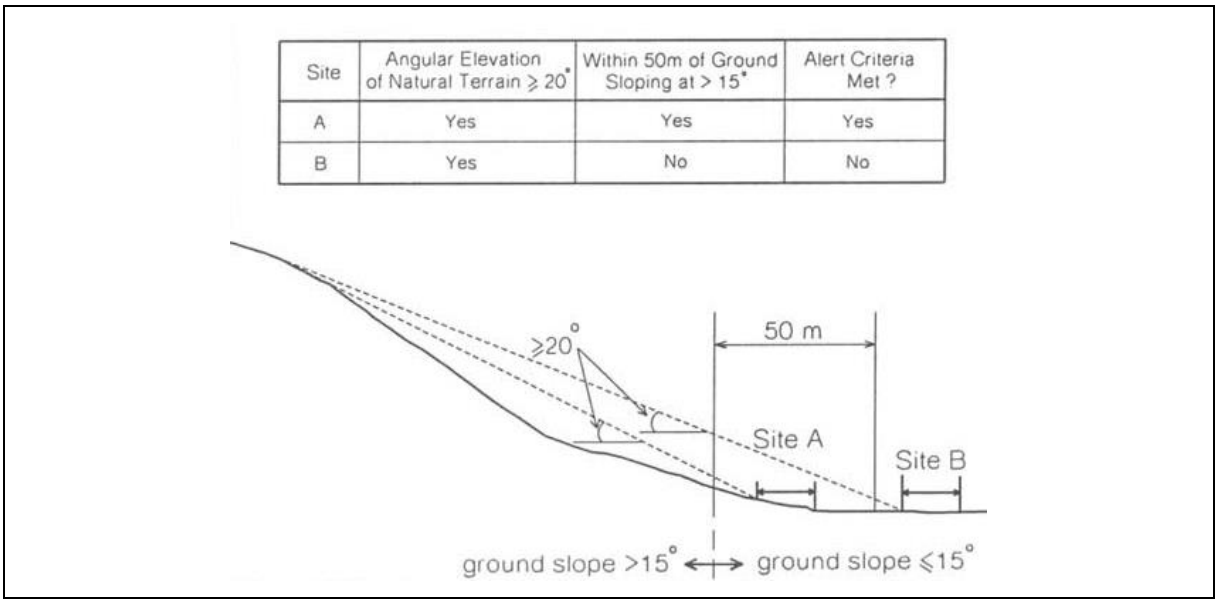


Figure 2.1 Graphical Presentation of the Alert Criteria

Another example would be a site that is shielded from debris by a substantial structure such as a large building; and

(c) In applying the Alert Criteria to help decide whether an NTHS is required for a site, professional judgement is to be exercised with account taken of the nature of the proposed development, its proximity to the hillside, size and geometry of the site, and available information on the conditions and history of the hillside. In addition to recommending that an NTHS be carried out, consideration is also given to alternative means for dealing with natural terrain hazards. These include adjustment of the layout of the proposed development, delineation of no-build zones, simple drainage provisions, etc.

3 Methodology

The Alert Criteria were developed in the late 1990s based on the consideration of the following:

(a) Travel angles of all recent natural terrain landslides in the Natural Terrain Landslide Inventory (NTLI), which was compiled using high-level aerial photographs (King, 1999); and

(b) Toe slope angles and runout distances beyond ≤ 15° ground slope of all recent natural terrain landslides in the NTLI with landslide sources more than 15 m wide as confirmed

on low-level aerial photographs in the Large Landslide Study (LLS) (Scott Wilson, 1999).

Tables 3.1 to 3.3 show respectively the previous percentage distribution of travel angles, toe slope angles and runout distances beyond ≤ 15° ground slope of landslides recorded in the NTLI. The tables help to identify hillside areas which could possibly be impacted by landslide debris and therefore areas where planning of new developments should include an assessment of potential natural terrain hazards.

Based on the analyses of the travel angles of 3,316 NTLI recent landslides, and the toe slope angles and runout distances of 560 large NTLI recent landslides, it was concluded to adopt the following criteria as the Alert Criteria: the travel angle from potential source areas should be ≥ 20° and the area should not be more than 50 m downhill from a ground slope angle of 15°. These two criteria encompassed respectively 97% and 99% of the analysed landslide debris trails and were considered adequately representative.

The review of the Alert Criteria in the present study follows largely the above methodology, with updates on the sources of landslide and topographic data and the use of the latest GIS technology. Details of the analyses are given below.

Table 3.1 Previous Percentage Distribution of Travel Angles of Natural Terrain Landslides in NTLI

Travel Angle	All			Source Width > 20 m wide		
	No. of Record	% of Total	Cumulative %	No. of Record	% of Total	Cumulative %
> 55°	15	0.45%	0.45%	0	0.00%	0.00%
50° - 55°	39	1.18%	1.63%	0	0.00%	0.00%
45° - 50°	105	3.17%	4.79%	5	1.42%	1.42%
40° - 45°	257	7.75%	12.55%	18	5.13%	6.55%
35° - 40°	635	19.15%	31.69%	54	15.38%	21.94%
30° - 35°	973	29.34%	61.04%	116	33.05%	54.99%
25° - 30°	880	26.54%	87.58%	112	31.91%	86.89%
20° - 25°	314	9.47%	97.04%	35	9.97%	96.87%
15° - 20°	87	2.62%	99.67%	10	2.85%	99.72%
10° - 15°	8	0.24%	99.91%	0	0.00%	99.72%
5° - 10°	3	0.09%	100.00%	1	0.28%	100.00%
0° - 5°	0	0.00%	100.00%	0	0.00%	100.00%
Total	3316	100.00%		351	100.00%	

Table 3.2 Previous Percentage Distribution of Toe Slope Angles of Natural Terrain Landslides in NTLI with Source Width > 15 m

Toe Slope Angle	No. of Record	% of Total	Cumulative %
> 55°	4	0.71%	0.71%
50° - 55°	2	0.36%	1.07%
45° - 50°	16	2.86%	3.93%
40° - 45°	28	5.00%	8.93%
35° - 40°	57	10.18%	19.11%
30° - 35°	108	19.29%	38.39%
25° - 30°	128	22.86%	61.25%
20° - 25°	77	13.75%	75.00%
15° - 20°	73	13.04%	88.04%
10° - 15°	42	7.50%	95.54%
5° - 10°	19	3.39%	98.93%
0° - 5°	6	1.07%	100.00%
Total	560	100.00%	

Table 3.3 Previous Percentage Distribution of Runout Distances beyond ≤ 15° Ground Slope of Natural Terrain Landslides in NTLI with Source Width > 15 m

Runout Distance (m)	No. of Record	% of Total Database (560)
0 - 10	27	4.82%
10 - 20	21	3.75%
20 - 30	10	1.79%
30 - 40	6	1.07%
40 - 50	1	0.18%
50 - 60	1	0.18%
60 - 70	1	0.18%
70 - 80	0	0.00%
Total	67	11.96%

3.1 Landslide and Topographic Data

Previously, the recent landslides in the NTLI were used to develop the Alert Criteria. The NTLI was compiled from interpretation of high-level aerial photographs, and the landslide locations were plotted on the 1:5000-scale topographic maps and data were tabulated for each landslide (King, 1999).

In the present study, the recent landslides in the ENTLI (as of 2009) with both their crown and toe locations within natural hillsides have been selected for the analyses. The ENTLI was compiled from interpretation of low-level aerial photographs and the landslide locations were digitized on the 1:1000-scale topographic maps. Landslide data were then collated from the topographic maps using GIS technology.

3.2 Travel Angle

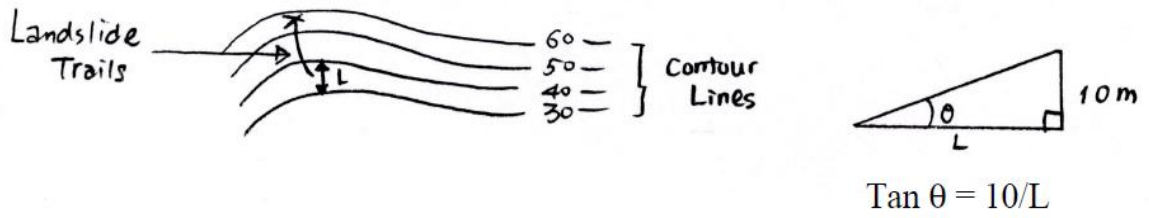
Previously, the travel angles of all recent landslides in the NTLI were computed using the landslide data, i.e. the elevation of the landslide crowns and toes, in the NTLI together with their runout distances.

In the present study, the travel angles of all recent landslides in the ENTLI (as of 2009) with both their crown and toe locations within natural hillsides were calculated in a similar manner, but using the latest landslide data in the ENTLI.

3.3 Toe Slope Angle and Runout Distance beyond ≤ 15° Ground Slope

Previously, recent landslides with sources more than 20 m wide in the NTLI were included in the LLS for review. The LLS confirmed, with the use of low-level aerial photographs, 560 recent landslides with a minimum source width of 15 m. These 560 large confirmed recent landslides in general had longer runout distances as compared to the landslides of smaller volumes. In determining how far landslides would travel beyond ≤ 15° ground slope, the long-runout landslides would give a generally conservative estimate of debris runout and therefore they were considered representative for the collection of data on toe slope angle and runout distance beyond ≤ 15° ground slope (Choi et al, 2003). The toe slope angles and runout distances beyond ≤ 15° ground slope of the natural terrain landslides were measured from the 1:5000-scale topographic map contours by hand based on the original hand drawn 1:5000-scale NTLI maps (Figures 3.1 and 3.2).

(a) The distance L that is perpendicular to the last two contour lines at the end of a landslide trail was measured and the toe slope angle was obtained by trigonometry.



(b) If the toe of a landslide is touching a contour, an average was taken for the distance between the two adjacent contours.

Figure 3.1 Previous Approach to Measure Toe Slope Angle (extracted from Choi et al, 2003)

All measured distances between two contours larger than 7.5 mm represent slopes of less than 15°. Therefore the 15° break in slope was defined as the upper contour of the first pair of contours with spacing larger than 7.5 mm. The length of the landslide trail that extended beyond the 15° break in slope was measured and recorded.

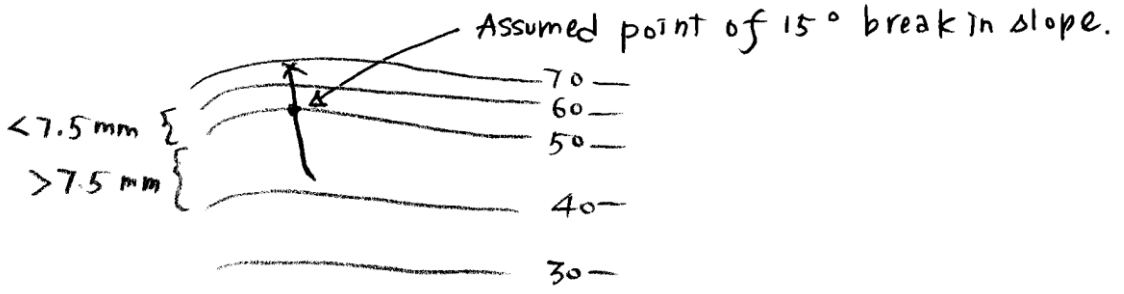


Figure 3.2 Previous Approach to Measure Runout Distance beyond ≤ 15° Ground Slope (extracted from Choi et al, 2003)

In the present study, measurements of toe slope angle and runout distance beyond ≤ 15° ground slope have been undertaken using the HKSAR-wide digital elevation model (DEM) (2 m × 2 m grid) derived from the 1:1000-scale topographic maps in GIS. Figure 3.3 illustrates the measurement approaches for toe slope angle and runout distance beyond ≤ 15° ground slope. The original approach of making measurements based on contour lines in the topographic maps is largely followed but this time with an enhancement in the map resolution (i.e. from 10 m intervals to 2 m intervals), and the use of digital topographic data and the latest GIS technology. This has greatly enhanced the efficiency of the measurements and the accuracy of the measurement results.

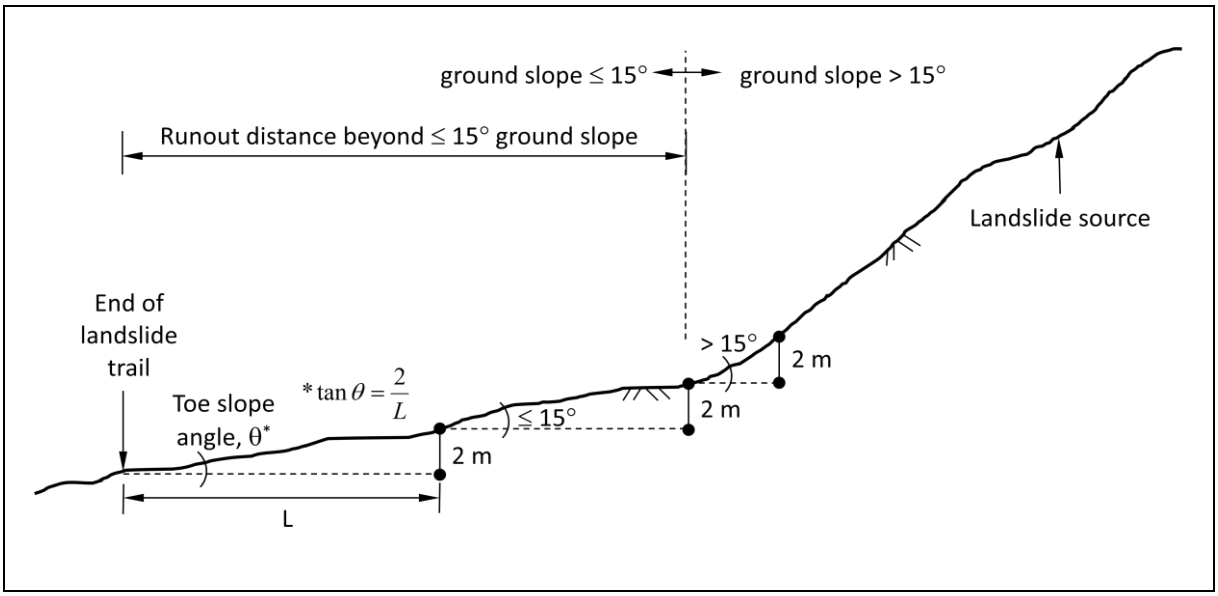


Figure 3.3 Present Approach to Measure Toe Slope Angle and Runout Distance beyond ≤ 15° Ground Slope

4 Findings

The updated statistics for travel angle, toe slope angle and runout distance beyond ≤ 15° ground slope are given in Tables 4.1, 4.2 and 4.3 respectively.

It is noted from Table 4.1 that the first criterion of the Alert Criteria - "where there is natural terrain outside the site, but within the same catchment, that is at an angular elevation of 20° or more from the site" encompasses 96% of the large recent natural terrain landslides (i.e. with source width more than 15 m). The second criterion - "where there is ground sloping at more than 15° within 50 m horizontally upslope of the site" covers 98% of the large recent natural terrain landslides (Tables 4.2 to 4.3).

Table 4.4 shows the differences in the cumulative percentages of natural terrain landslides covered by the two criteria under the Alert Criteria between the previous and present studies. It indicates that the variations are only about 1%. The Alert Criteria are still representative of the majority of the natural terrain landslides. Change to the Alert Criteria is therefore considered not necessary at this stage.

Table 4.1 Updated Percentage Distribution of Travel Angles of Natural Terrain Landslides in ENTLI

Travel Angle (°)		Channelized Debris Flows (C)						Open Hillslope Landslides (O)						Both C and O					
		All			Source Width > 15 m			All			Source Width > 15 m			All			Source Width > 15 m		
from	to	No. of C	% of C	Cum % of C	No. of C	% of C	Cum % of C	No. of O	% of O	Cum % of O	No. of O	% of O	Cum % of O	No. of All	% of All	Cum % of All	No. of All	% of All	Cum % of All
55	90	6	0.1%	0.1%	1	0.2%	0.2%	33	0.3%	0.3%	0	0.0%	0.0%	39	0.2%	0.2%	1	0.1%	0.1%
50	55	13	0.2%	0.3%	0	0.0%	0.2%	121	1.1%	1.4%	1	0.2%	0.2%	134	0.8%	1.0%	1	0.1%	0.2%
45	50	58	0.9%	1.2%	1	0.2%	0.4%	365	3.2%	4.6%	4	0.9%	1.1%	423	2.4%	3.4%	5	0.5%	0.7%
40	45	259	4.2%	5.4%	9	1.9%	2.3%	1103	9.7%	14.2%	23	4.9%	6.0%	1362	7.7%	11.1%	32	3.4%	4.1%
35	40	910	14.6%	20.0%	35	7.3%	9.6%	2708	23.8%	38.0%	90	19.3%	25.3%	3618	20.5%	31.7%	125	13.3%	17.4%
30	35	1894	30.4%	50.4%	131	27.5%	37.1%	3832	33.7%	71.7%	195	41.8%	67.2%	5726	32.5%	64.2%	326	34.6%	52.0%
25	30	1960	31.4%	81.8%	169	35.4%	72.5%	2370	20.8%	92.5%	120	25.8%	92.9%	4330	24.6%	88.7%	289	30.6%	82.6%
20	25	883	14.2%	96.0%	93	19.5%	92.0%	675	5.9%	98.4%	31	6.7%	99.6%	1558	8.8%	97.6%	124	13.1%	95.8%
15	20	207	3.3%	99.3%	34	7.1%	99.2%	147	1.3%	99.7%	1	0.2%	99.8%	354	2.0%	99.6%	35	3.7%	99.5%
10	15	39	0.6%	99.9%	4	0.8%	100.0%	28	0.2%	100.0%	1	0.2%	100.0%	67	0.4%	100.0%	5	0.5%	100.0%
5	10	4	0.1%	100.0%	0	0.0%	100.0%	2	0.0%	100.0%	0	0.0%	100.0%	6	0.0%	100.0%	0	0.0%	100.0%
0	5	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
		6233			477			11384			466			17617			943		

Note: C = Channelized debris flows;
O = Open hillslope landslides; and
Cum % = Cumulative %.

Table 4.2 Updated Percentage Distribution of Toe Slope Angles of Natural Terrain Landslides in ENTLI

Toe Slope Angle (°)		Channelized Debris Flows (C)						Open Hillslope Landslides (O)						Both C and O					
		All			Source Width > 15 m			All			Source Width > 15 m			All			Source Width > 15 m		
from	to	No. of C	% of C	Cum % of C	No. of C	% of C	Cum % of C	No. of O	% of O	Cum % of O	No. of O	% of O	Cum % of O	No. of All	% of All	Cum % of All	No. of All	% of All	Cum % of All
55	90	22	0.4%	0.4%	5	1.0%	1.0%	112	1.0%	1.0%	2	0.4%	0.4%	134	0.8%	0.8%	7	0.7%	0.7%
50	55	32	0.5%	0.9%	1	0.2%	1.2%	170	1.5%	2.5%	6	1.3%	1.7%	202	1.1%	1.9%	7	0.7%	1.5%
45	50	123	2.0%	2.8%	5	1.0%	2.3%	479	4.2%	6.7%	12	2.5%	4.2%	602	3.4%	5.3%	17	1.8%	3.2%
40	45	267	4.3%	7.1%	19	4.0%	6.2%	850	7.5%	14.1%	27	5.7%	9.9%	1117	6.3%	11.6%	46	4.8%	8.1%
35	40	528	8.4%	15.5%	25	5.2%	11.4%	1679	14.7%	28.8%	56	11.8%	21.8%	2207	12.5%	24.1%	81	8.5%	16.6%
30	35	855	13.6%	29.1%	60	12.5%	23.9%	2200	19.3%	48.1%	87	18.4%	40.2%	3055	17.3%	41.4%	147	15.4%	32.0%
25	30	1371	21.8%	50.9%	83	17.3%	41.2%	2817	24.7%	72.8%	106	22.4%	62.6%	4188	23.7%	65.1%	189	19.8%	51.8%
20	25	1140	18.2%	69.1%	85	17.7%	58.8%	1678	14.7%	87.5%	77	16.3%	78.9%	2818	15.9%	81.0%	162	17.0%	68.8%
15	20	1073	17.1%	86.2%	89	18.5%	77.3%	1056	9.3%	96.8%	66	14.0%	92.8%	2129	12.0%	93.0%	155	16.2%	85.0%
10	15	615	9.8%	96.0%	74	15.4%	92.7%	312	2.7%	99.5%	30	6.3%	99.2%	927	5.2%	98.3%	104	10.9%	95.9%
5	10	219	3.5%	99.5%	29	6.0%	98.8%	52	0.5%	100.0%	4	0.8%	100.0%	271	1.5%	99.8%	33	3.5%	99.4%
0	5	33	0.5%	100.0%	6	1.2%	100.0%	2	0.0%	100.0%	0	0.0%	100.0%	35	0.2%	100.0%	6	0.6%	100.0%
		6278			481			11407			473			17685			954		

Note: C = Channelized debris flows;
O = Open hillslope landslides; and
Cum % = Cumulative %.

Table 4.3 Updated Percentage Distribution of Runout Distances of Natural Terrain Landslides in ENTLI that Run beyond ≤ 15° Ground Slope

Runout Distance (m)		Channelized Debris Flows (C)						Open Hillslope Landslides (O)						Both C and O					
		All			Source Width > 15 m			All			Source Width > 15 m			All			Source Width > 15 m		
from	to	No. of C	% of C	Cum % of C	No. of C	% of C	Cum % of C	No. of O	% of O	Cum % of O	No. of O	% of O	Cum % of O	No. of All	% of All	Cum % of All	No. of All	% of All	Cum % of All
0	10	6	0.7%	0.7%	1	0.9%	0.9%	15	4.1%	4.1%	2	5.9%	5.9%	21	1.7%	1.7%	3	2.1%	2.1%
10	20	486	56.1%	56.7%	49	45.0%	45.9%	295	80.6%	84.7%	24	70.6%	76.5%	781	63.3%	65.0%	73	51.0%	53.1%
20	30	159	18.3%	75.1%	21	19.3%	65.1%	45	12.3%	97.0%	6	17.6%	94.1%	204	16.5%	81.6%	27	18.9%	72.0%
30	40	73	8.4%	83.5%	10	9.2%	74.3%	8	2.2%	99.2%	1	2.9%	97.1%	81	6.6%	88.2%	11	7.7%	79.7%
40	50	44	5.1%	88.6%	8	7.3%	81.7%	3	0.8%	100.0%	1	2.9%	100.0%	47	3.8%	92.0%	9	6.3%	86.0%
50	100	69	8.0%	96.5%	16	14.7%	96.3%	0	0.0%	100.0%	0	0.0%	100.0%	69	5.6%	97.6%	16	11.2%	97.2%
100	200	24	2.8%	99.3%	4	3.7%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	24	1.9%	99.5%	4	2.8%	100.0%
200	300	0	0.0%	99.3%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	99.5%	0	0.0%	100.0%
300	400	2	0.2%	99.5%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	2	0.2%	99.7%	0	0.0%	100.0%
400	500	4	0.5%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	4	0.3%	100.0%	0	0.0%	100.0%
500	1000	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
1000	2000	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
		867			109			366			34			1233			143		

Note: C = Channelized debris flows;
O = Open hillslope landslides; and
Cum % = Cumulative %.

Table 4.4 Differences in Cumulative Percentages of Natural Terrain Landslides Covered by the Two Criteria under the Alert Criteria

	Previous Study	Present Review
Travel angle > 20°	97%	96%
Runout not more than 50 m beyond ≤ 15°	99%	98%

It should be highlighted that the Alert Criteria cover almost 100% of the large recent open hillslope landslides. However, the Alert Criteria have relatively lower performance for channelized debris flows (CDFs). Tables 4.1 to 4.3 indicate that the first criterion of the Alert Criteria represents only 92% of the large recent CDFs while the second criterion takes in 96% of the landslides. As such, when evaluating a site for NTHS, the supplementary guidance (a) indicated in Section 2 above should be duly considered, especially for sites overlooked by hillside catchments with major drainage lines.

5 Key Observations

Recent landslides in the ENTLI (as of 2009) with both their crown and toe locations within natural hillsides have been selected for measurements of travel angle, toe slope angle and runout distance beyond ≤ 15° ground slopes in the present review. The use of the landslide data in the ENTLI has no doubt enhanced the resolution and accuracy of the measurements as the ENTLI was compiled from interpretation of low-level aerial photographs and the landslide data were collated from the 1:1000-scale topographic maps using the latest GIS technology. The use of the landslide data in the ENTLI has also eliminated possible human errors that might have been involved in the reading of landslide information by naked eyes from the original hand drawn 1:5000-scale topographic maps as was done in the previous study.

Only recent landslides in the ENTLI with both their crown and toe locations within natural hillsides have been selected because they contain landslide data (i.e. elevation of landslide crown and toe, and runout distance) required for measuring travel angle, toe slope angle and runout distance beyond ≤ 15° ground slope. As developments gradually encroach into the natural hillsides, some landslides that have once occurred within natural hillsides may now have their crowns or toes or both shown within developed areas on the latest topographic maps. The elevation data of these landslides as collated from the topographic maps would no longer be genuine and therefore, they have been excluded from the present study.

In the previous study, the toe slope angle of a landslide was taken as the average slope angle between two successive contour lines at the toe of the landslide (see Figure 3.1). The contour lines are at 10 m intervals in the 1:5000-scale topographic maps. In the present study, the measurement of toe slope angle is slightly revised (see Figure 3.3) in order to streamline the calculation process. The slope angle of the last 2 m (in elevation) of a landslide trail is taken as the toe slope angle of the landslide. The revised approach should not produce results too much different from those derived from the previous approach, as now

the contour lines are at 2 m intervals in the 1:1000-scale topographic maps and the change in ground levels within any half to one contour-spacing should not be significant.

6 Conclusions

The Alert Criteria have been reviewed using the most up-to-date landslide data in the ENTLI and the 1:1000-scale topographic maps, together with the latest GIS technology. The resolution and accuracy of the measurements of travel angle, toe slope angle and runout distance beyond ≤ 15° ground slope are greatly enhanced. As a result, findings of the review are much more reliable and representative.

The findings of the review indicate only minor variations in the cumulative percentages of natural terrain landslides covered by the two criteria under the "Alert Criteria", as compared to the previous study. Change to the Alert Criteria is therefore considered not necessary at this stage.

7 References

Choi, A.S.W., Fung, E.K.S., Law, A.M.H. & King, J.P. (2003). *Toe Slope Angle of Natural Terrain Landslides (Section 2 of GEO Report No. 134)*. Geotechnical Engineering Office, Hong Kong, 44 p.

King, J.P. (1999). *Natural Terrain Landslide Study: The Natural Terrain Landslide Inventory (GEO Report No. 74)*. Geotechnical Engineering Office, Hong Kong, 127 p.

Ng, K.C., Parry, S., King, J.P., Franks, C.A.M. & Shaw, R. (2003). *Guidelines on Natural Terrain Hazard Studies (GEO Report No. 138)*. Geotechnical Engineering Office, Hong Kong, 138 p.

Scott Wilson (1999). *Specialist API Services for the Natural Terrain Landslide Study, Task B Factual Report*. Report prepared by Scott Wilson (Hong Kong) Ltd. Geotechnical Engineering Office, Hong Kong, 9 p. plus 4 Appendices.

GEO PUBLICATIONS AND ORDERING INFORMATION
土力工程處刊物及訂購資料

An up-to-date full list of GEO publications can be found at the CEDD Website http://www.cedd.gov.hk on the Internet under "Publications". The following GEO publications can also be downloaded from the CEDD Website:

i. Manuals, Guides and Specifications
ii. GEO technical guidance notes
iii. GEO reports
iv. Geotechnical area studies programme
v. Geological survey memoirs
vi. Geological survey sheet reports

詳盡及最新的土力工程處刊物目錄，已登載於土木工程拓展署的互聯網網頁http://www.cedd.gov.hk 的"刊物"版面之內。以下的土力工程處刊物亦可於該網頁下載：

i. 指南、指引及規格
ii. 土力工程處技術指引
iii. 土力工程處報告
iv. 岩土工程地區研究計劃
v. 地質研究報告
vi. 地質調查圖表報告

Copies of some GEO publications (except geological maps and other publications which are free of charge) can be purchased either by:

Writing to
Publications Sales Unit,
Information Services Department,
Room 626, 6th Floor,
North Point Government Offices,
333 Java Road, North Point, Hong Kong.

or

- Calling the Publications Sales Section of Information Services Department (ISD) at (852) 2537 1910
- Visiting the online Government Bookstore at http:// www.bookstore.gov.hk
- Downloading the order form from the ISD website at http://www.isd.gov.hk and submitting the order online or by fax to (852) 2523 7195
- Placing order with ISD by e-mail at puborder@isd.gov.hk

讀者可採用以下方法購買部分土力工程處刊物(地質圖及免費刊物除外):

書面訂購
香港北角渣華道333號
北角政府合署6樓626室
政府新聞處
刊物銷售組

或

- 致電政府新聞處刊物銷售小組訂購 (電話：(852) 2537 1910)
- 進入網上「政府書店」選購，網址為 http://www.bookstore.gov.hk
- 透過政府新聞處的網站 (http://www.isd.gov.hk) 於網上遞交訂購表格，或將表格傳真至刊物銷售小組 (傳真：(852) 2523 7195)
- 以電郵方式訂購 (電郵地址：puborder@isd.gov.hk)

1:100 000, 1:20 000 and 1:5 000 geological maps can be purchased from:

Map Publications Centre/HK,
Survey & Mapping Office, Lands Department,
23th Floor, North Point Government Offices,
333 Java Road, North Point, Hong Kong.
Tel: (852) 2231 3187
Fax: (852) 2116 0774

讀者可於下列地點購買1:100 000、1:20 000及1:5 000地質圖：

香港北角渣華道333號
北角政府合署23樓
地政總署測繪處
電話: (852) 2231 3187
傳真: (852) 2116 0774

Any enquires on GEO publications should be directed to:

Chief Geotechnical Engineer/Standards and Testing,
Geotechnical Engineering Office,
Civil Engineering and Development Department,
Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon, Hong Kong.
Tel: (852) 2762 5346
Fax: (852) 2714 0275
E-mail: frankielclo@cedd.gov.hk

如對本處刊物有任何查詢，請致函：

香港九龍何文田公主道101號
土木工程拓展署大樓
土木工程拓展署
土力工程處
標準及測試部總土力工程師
電話: (852) 2762 5346
傳真: (852) 2714 0275
電子郵件: frankielclo@cedd.gov.hk