

GEO Technical Guidance Note No. 46 (TGN 46)
**Supplementary Guidelines on Natural Terrain Hazard Studies for
Hillside Pockets**

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1. SCOPE

- 1.1 This Technical Guidance Note (TGN) presents guidelines on natural terrain hazard studies (NTHS) for hillside catchments with Hillside Pocket-type settings (referred to as Hillside Pockets, HP). This TGN is intended to provide supplementary guidelines for undertaking NTHS and provide additional guidance on the mitigation strategy for Hillside Pockets.
- 1.2 Any feedback on this TGN should be directed to the Chief Geotechnical Engineer/Planning of GEO.

2. TECHNICAL POLICY

- 2.1 The technical recommendations promulgated in this TGN were agreed by the GEO Geotechnical Control Conference (GCC) on 11 March 2016.
- 2.2 The supplementary guidelines should be adopted for HP included in the Landslip Prevention and Mitigation Programme (LPMitP) with immediate effect. The technical recommendations outlined in paragraphs 6.4 to 6.14 are applicable to HP included in non-LPMitP projects including public works projects, private developments/redevelopments and Housing Department projects.

3. RELATED DOCUMENTS

- 3.1 GEO (2014). *Guidelines on Empirical Design of Flexible Barriers for Mitigating Natural Terrain Open Hillslope Landslide Hazards (TGN 37)*. Geotechnical Engineering Office, Hong Kong.
- 3.2 Ho, H.Y. & Roberts, K.J. (2016). *Guidelines for Natural Terrain Hazard Studies (GEO Report No. 138, 2nd Edition)*. Geotechnical Engineering Office, Hong Kong.

4. BACKGROUND

- 4.1 Given the history of infrastructure and building development on Hong Kong's foothills, small tracts of hillsides within developed areas are common. HP, which are a form of natural hillside catchment, are affected by human disturbance to varying degrees (e.g. construction of roads or building platforms).
- 4.2 Based on a review of previous landslides that have occurred within HP, the probable contributing factors to the landslides include presence of loose fill, inadequate drainage provision, presence of disturbed ground and poor slope surface protection.

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- 4.3 Given that the site setting of HP is different from typical natural hillsides, significant landslide risk may be posed by certain HP that do not meet the Historical Landslide Catchment (HLC) selection criteria.
- 4.4 GEO has recently compiled an inventory of HP for the whole of Hong Kong. Vulnerable HP refer to those affecting toe facilities of consequence-to-life (CTL) Category 1 (i.e. buildings, important transport corridors and infrastructure), with landslides (including landslides in the Enhanced Natural Terrain Landslide Inventory or the GEO landslide incident database) and/or those with known disturbance (i.e. registered Disturbed Terrain features).
- 4.5 All the vulnerable HP have been included in a combined priority ranking list (i.e. HLC and HP) for action under LPMitP.

5. DEFINITIONS

- 5.1 Nil.

6. TECHNICAL RECOMMENDATIONS

Application of Guidelines on the Enhanced Approach for Hillside Pockets

- 6.1 Under the enhanced approach for dealing with natural terrain hazards as set out in the 2nd Edition of GEO Report No. 138 (Ho & Roberts, 2016), the NTHS under LPMitP are divided into Natural Terrain Hazard Review (NTHR) and Natural Terrain Hazard Assessment (NTHA) stages. At the NTHR stage, deliberation of whether or not the catchments meet the ‘react-to-known-hazard’ principle is required.
- 6.2 In dealing with HP, guidelines on the enhanced approach are generally applicable except that any open hillslope (OH) catchment not meeting the ‘react-to-known-hazard’ principle must still proceed to the NTHA stage with detailed evaluation of these catchments, including ground investigation (GI), if necessary, given that the contributing factors to the landslides are different to that of natural hillsides.
- 6.3 An area-based approach, similar to that for HLC, should be adopted under the LPMitP, whereby adjoining lower-ranked and/or non-CTL Category 1 HP that have similar topographical, geological and geomorphological setting are combined in study packages. This approach allows HP that are of similar nature to be studied in one go and to assess any necessary preventive or mitigation works required based on the NTHA findings.

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Hazard Factors Relating to Assessment of Hillside Pockets

- 6.4 The hazard assessment for HP should follow the guidelines given in GEO Report No. 138 (2nd Edition). In particular, the following hazard factors associated with HP settings should also be duly considered:
- (a) presence of recognizable fill bodies (plan area >10 m²) with adverse site setting (e.g. a fill body located at the upper portion of a catchment on steep terrain with a slope gradient >30°, and with a credible flow path reaching the facility at risk);
 - (b) adequacy of drainage provisions at the crest and within the HP, specifically the likelihood of any possible concentration of surface water onto the HP; and
 - (c) condition of surface protection (e.g. cracks on the hard surfacing).

Mitigation Strategy for Hillside Pockets

- 6.5 The typical setting of a HP within the densely developed urban area means that a number of constraints will require careful review and consideration when determining the most appropriate mitigation scheme. These include, but are not limited to, the following items:
- (a) presence of private lots;
 - (b) access for GI and mitigation works;
 - (c) presence of steep man-made slopes at the toe and issues associated with surcharge loading onto these slopes;
 - (d) discharge of surface water run-off from the developed area above onto the HP;
 - (e) visual impact to nearby residents and the public in general;
 - (f) buildability of the measures proposed; and
 - (g) landscaping treatment.
- 6.6 Preventive and mitigation measures have been successfully implemented in some LPMit projects involving HP. These include:
- (a) local soil nails to stabilize landslide source areas or local steep terrain;
 - (b) removal / re-compaction of loose fill bodies;
 - (c) improved drainage provisions;
 - (d) in-situ stabilization or removal of boulders;
 - (e) soil bioengineering techniques for surface erosion protection; and
 - (f) debris resisting barrier along the toe.

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- 6.7 The Factor of Safety approach can be considered in the study of HP especially for a small planar hillside where it may sometimes be cost-effective and environmentally acceptable to carry out soil nailing rather than installation of debris-resisting barriers.
- 6.8 Most landslides that have occurred within HP are shallow in nature (i.e. 0.5 to 2 m deep). When adopting the soil nailing option to provide an adequate factor of safety against failure of the regolith, an appropriate geological model should be developed in determining the credible slip surface. Furthermore, overly conservative groundwater conditions should be avoided. Some useful guidelines on this aspect are given in GEO TGN 37 (GEO, 2014).
- 6.9 Some HP may have been extensively modified by anthropogenic activities, e.g. fill platforms. Detailed aerial photograph interpretation (API) and field inspection should be carried out to delineate the extent and where possible depth of these fill bodies, and confirmed by GI as necessary. Suitable preventive or mitigation measures should be implemented based on analytical design.
- 6.10 As stipulated in GEO Report No. 138 (2nd Edition), cost effectiveness should be considered in both the GI as well as the formulation of the mitigation strategy, to ensure that the cost of which is not disproportionate to the level of landslide risk posed by the HP to the development. For HP affecting Group 2(b) and Group 3 facilities (refer to Table 2.2 of GEO Report No. 138, 2nd Edition), the following approaches should be adopted:
- (a) GI would normally be considered only if presence of fill bodies is suspected from API or field inspection.
 - (b) mitigation works are generally not required for these HP if the NTHA confirms all of the hazard factors stated in paragraphs 6.4(a) to 6.4(c) do not exist, unless there is evidence of persistent landslides and/or significant signs of distress.
- 6.11 With respect to paragraph 6.10 above, a holistic approach could be considered to protect the facilities at risk if mitigation actions are required at the adjacent catchments. In considering whether the holistic risk mitigation strategy should be adopted, judgement needs to be exercised taking into account the types of facility affected and their proximity from the catchment, and sound justifications should be provided.
- 6.12 Similar to typical natural hillsides, HP affecting Group 4 and 5 facilities (refer to Table 2.2 of GEO Report No. 138, 2nd Edition) normally do not require NTHS.

**Application of Guidelines on Empirical Design of Flexible Barriers for Mitigating
Open Hillslope Landslide Hazards for Hillside Pockets**

- 6.13 Given site constraints, it is often not practicable to provide substantial mitigation works,

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e.g. rigid barriers, for dealing with open hillslope landslide (OHL) hazards. Adopting empirical design based on the use of prescribed flexible barriers can be a practicable approach for mitigation of OHL hazard in general. Guidelines on empirical design of flexible barriers for mitigating natural terrain OHL have been set out in GEO TGN 37 (GEO, 2014). Adoption of these guidelines should be evaluated on a case-by-case basis.

- 6.14 Although flexible barriers are generally less visually intrusive than rigid barriers, they may still be considered undesirable where extensive flexible barriers are to be located in close proximity to residential buildings. This aspect should be carefully considered in the formulation of suitable mitigation options.

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