GEO Technical Guidance Note No. 16 (TGN 16)
Recommendations Arising from Review of Notable Landslide Incidents During Slope Works (1981 - 2002)

1. SCOPE

1.1 This Technical Guidance Note (TGN) outlines recommendations to mitigate the risk from landslides during slope works based on a review of notable landslide incidents that occurred between 1981 and 2002. The details of the review and its findings are documented by Sun & Tsui (2003).

1.2 Any feedback on this TGN should be directed to Chief Geotechnical Engineer/Landslip Preventive Measures 1 of the GEO.

2. TECHNICAL POLICY

2.1 The technical recommendations promulgated in this TGN were agreed by GEO Geotechnical Control Conference (GCC) on 22 October 2003.

3. RELATED DOCUMENTS

3.1 Geotechnical Engineering Office (2004). *Enhancing the Reliability and Robustness of Engineered Soil Cut Slopes*. GEO Technical Guidance Note No. 11, Geotechnical Engineering Office, Hong Kong, 8 p.

3.2 Sun, H.W. & Tsui, H.M. (2003). *Review of Notable Landslide Incidents During Slope Works*. Landslide Study Report No. LSR 5/2003, Geotechnical Engineering Office, Hong Kong, 147 p.

4. BACKGROUND

4.1 Slopes can be vulnerable to failure during the course of site formation or slope upgrading/improvement works (e.g. formation of temporary cuts, vegetation clearance, etc.), especially where the works are being carried out in the wet season. Adequate planning, scheduling and supervision of the works are important.

5. TECHNICAL RECOMMENDATIONS

5.1 Based on the observations made in the review of notable landslide incidents during slope works, the following areas are worthy of attention:

(a) Buildability of design - The buildability of permanent slope works design should be thoroughly considered by the designers in the option assessment stage as well as the detailed design stage to avoid conditions that may be particularly vulnerable to slope failures during construction. It is important to ensure that the method statements submitted by the contractor are appropriate and sufficiently

detailed including, where necessary, contingency measures to cater for possible changes in site or ground conditions.

(b) Management of site supervisory staff and audit of site works - The designer/project office should carry out the following:

(i) formulate a plan to manage the site supervisory staff and upkeep the standard of site supervision;

(ii) provide site supervisory staff with sufficient information/briefing for their appreciation of the geotechnical content of the works, key design assumptions and range of potential anomalies that could be encountered;

(iii) review regularly the adequacy of the site supervision staffing level and make necessary adjustments to suit the prevailing circumstances;

(iv) arrange for audits to be carried out without prior warning, particularly for critical site activities, to check the standard of site supervision (including site staff's familiarity and knowledge of the site activities and progress); and

(v) ensure that prompt action is taken to rectify the situation where non-compliances are identified by the audits and undertake follow-up audits to check and ensure the effectiveness of the rectification measures.

(c) Site supervision - An adequate site supervisory staffing level commensurate with the scale and complexity of the works should be provided. All critical works that will be buried in the ground whereby the quality of the as-built works will not be readily visible (e.g. insertion of steel reinforcement and grouting of soil nail drillholes, laying of drainage filter material and subsoil drain, etc.) should be supervised on a full-time basis with detailed records being kept. The competence of the site staff and their familiarity with the technical and contractual requirements of the project should be continually reviewed by the designer/project office. The site supervisory staff should:

(i) be fully briefed of their respective specific responsibilities, in particular their roles with respect to the qualified supervision system where appropriate and the day-to-day checks on the compliance with the specifications and the working procedures to ensure a high standard of workmanship and materials;

(ii) have a sufficient appreciation of the geotechnical content of the works and the key design assumptions;

(iii) be alert to the range of potential anomalies and prepare comprehensive records of relevant observations, such as signs of ground distress, suspected deviations from the design assumptions (e.g. high level seepage) or

discovery of unexpected water-carrying services, and seek assistance from the geotechnical supervision professionals; and

(iv) be particularly alert to identifying non-compliance with the specification or agreed method statements for temporary or permanent works and initiate prompt action to rectify the situation.

(d) Periodic supervision by geotechnical professionals - The suitably qualified geotechnical professional undertaking periodic supervision should liaise closely with the site supervisory staff regarding their site observations and should be satisfied during the site inspection that the works are not being carried out in such a manner as to invalidate the design assumptions. A prompt arrangement should be made for independent checking of any specific recommendations involving major changes in, or refinement of, the design. The possible need to seek further specialist advice from an experienced engineering geologist in geologically complex sites should also be considered where appropriate.

(e) Temporary support and protection - High, steep, unsupported temporary cuts should be avoided as far as possible. Adequate support must be provided to temporary cuts to maintain their stability. Where the construction involves a sizeable temporary cut in fill material or in geologically complex/ potentially problematic sites (GEO, 2003), the designer should carry out a stability analysis of the temporary cut. If the analysis indicates that substantial temporary work is required, it would be advisable for the designer to carry out the design of the temporary support, particularly for relatively small-sized slope works contracts. In this case, the required temporary works, including the construction sequence, should be specified in the design drawings. Where appropriate, the possibility of excessive ground movement affecting adjacent sensitive facilities due to the formation of a high, unsupported temporary cut should be assessed in addition to the stability of the cut face. Sufficient instrumentation of the adjacent facilities should be provided and suitable predetermined trigger levels for actions and predefined action plans and action parties should be established. During the wet season, temporary cuts or removal of existing hard surfacing/vegetated cover on slopes should be kept to the minimum required for the execution of the works. Adequate temporary protection should be provided to all such exposed faces. Where an impermeable surface cover is to be applied to a cut face, in particular a temporary cut, adequate provisions should be made to maintain the functions of all existing subsurface drainage measures behind the slope face (e.g. drainage blankets and raking drains). For any temporary cut faces that are expected to be exposed for a prolonged period of time during the course of the work, the designer should consider specifying the necessary temporary surface protection, such as shotcreting, in the design drawings.

(f) Temporary surface drainage - Sufficient temporary drainage must be provided at all times, especially during the wet season, to avoid the adverse effects of uncontrolled concentrated water ingress or surface water flow. The temporary

site drainage should be maintained and cleared of any blockage on a regular basis to ensure that the drains remain functional at times of heavy rainfall. The contractor should be encouraged, or required where appropriate, to construct part of the permanent drainage measures (e.g. crest drain and the associated discharge points) at an early stage of the works to enhance the temporary drainage provisions. The assessment of the adequacy of temporary drainage should take account of the overall site setting in an integrated manner, with due consideration given to the possible influence of adverse topography and impact of adjacent works where appropriate, especially for vulnerable and sensitive sites (e.g. where the failure consequences can be severe).

(g) Management of earthworks - For sites involving earthworks, particularly in a congested works area, due attention must be given to the proper management of excavated spoil or imported fill through proper planning and good house-keeping to prevent significant stockpiles of uncompacted soil that are unprotected against infiltration, as such loose material is vulnerable to sudden and mobile failure upon water ingress.

(h) Non-compliance/poor workmanship - Any discovery of non-compliance should be reported to the designer/project office as soon as possible. Follow-up actions should be stepped up progressively by the site supervisory staff against repeated non-compliances by the contractor, such as ordering the rectification of observed non-compliance to be completed within a short period of time, suspension of the works or undertaking emergency measures, following consultation with the designer/project office as appropriate. Apparent temporary stability of works that do not comply with the specifications or the agreed method statements during dry weather can give a false sense of security as failures are liable to occur without much prior warning, or with insufficient time to take rectification actions, during sudden intense rainstorms. Apart from the routine compliance tests stipulated in the specification for quality control, further compliance tests (e.g. on the finished work) may be included as part of the site audits as appropriate in order to detect, and deter, non-compliance and poor workmanship. For instance, for soil nailing works, these may involve non-destructive tests on randomly selected working soil nails to check the length of the reinforcement, exposing a section of constructed soil nail (e.g. by an inspection pit near slope surface or a trial pit from slope berm) to inspect the integrity of the grout annulus. For compaction work, this could include in-situ density tests on the compacted fill.

6. ANNEXES

6.1 Nil.

(R K S Chan)
Head, Geotechnical Engineering Office