GEO Technical Guidance Note No. 4 (TGN 4)
Guidelines on Recognition of Geological Features Hosting, and Associated with, Silt- and Clay-rich Layers Affecting the Stability of Cut Slopes in Volcanic and Granitic Rocks

1. SCOPE

1.1 This Technical Guidance Note (TGN) presents guidelines for recognising site conditions indicating the presence of geological features hosting, and associated with, silt- and clay-rich layers (predominantly kaolin) [Note (1)], that may have an influence on the stability of cut slopes in volcanic and granitic rocks. This TGN is not intended to cover all geological features that may influence the stability of cut slopes. Dimensions of features provided below are approximate only and should not be used in any absolute sense.

1.2 Any feedback on this TGN should be directed to Chief Geotechnical Engineer/Planning of the GEO.

2. TECHNICAL POLICY

2.1 The technical guidelines promulgated in this TGN were agreed by GEO's Geotechnical Control Conference (GCC) in April 2001.

3. RELATED DOCUMENTS

3.1 Campbell, S.D.G. & Koor, N.P. (1998). *Assessment of Geological Features Related to Recent Landslides in Volcanic Rocks in Hong Kong, Phase 2A – Chai Wan Study Area.* GEO Report No. 60, Geotechnical Engineering Office, Hong Kong, 78 p.

3.2 Campbell, S.D.G., Koor, N.P., Franks, C.A.M. & Shum, W.L. (1997). Geological assessment of slopes in areas close to major landslides in Hong Kong Island. K.S. Li, J.N. Kay & K.K.S. Ho (editors). *Proceedings of the Annual Seminar on Slope Engineering in Hong Kong*, Balkema, Rotterdam, pp 121-128.

3.3 Churchman, G.J., Pontifex, I.R. & McClure, S.G. (2001). *Mineralogical and shear strength study of clay-rich saprolite in Hong Kong – Mineralogical testing*. Summary report by CSIRO to Geotechnical Engineering Office, Hong Kong, 94 p.

3.4 Franks, C.A.M., Campbell, S.D.G. & Shum, W.W.L. (1999). *Assessment of Geological Features Related to Recent Landslides in Volcanic Rocks in Hong Kong, Phase 2B – Aberdeen Study Area.* GEO Report No. 67, Geotechnical Engineering Office, Hong Kong, 106 p.

3.5 Franks, C.A.M., Koor, N.P. & Campbell, S.D.G. (1998). An integrated approach to the assessment of slope stability in urban areas in Hong Kong using thematic maps. D. Moore & O. Hungr (editors). *Proceedings of the Eighth International Congress, International Association for Engineering Geology and the Environment*, Vancouver, September 1998, Balkema, Rotterdam, pp 1103-1111.

3.6 Fugro Maunsell Scott Wilson Joint Venture (2000). *Report on the Shek Kip Mei Landslide of 25 August 1999, Volume 1 – Findings of the Landslide Investigation*. Report for the Geotechnical Engineering Office, Hong Kong, 156 p.

3.7 Geotechnical Control Office (1987). *Guide to Site Investigation, Geoguide 2*. Geotechnical Control Office, Hong Kong, 362 p.

3.8 Geotechnical Control Office (1988). *Guide to Rock and Soil Descriptions, Geoguide 3*. Geotechnical Control Office, Hong Kong, 189 p.

3.9 Geotechnical Engineering Office (1996a). *Report on the Fei Tsui Road Landslide of 13 August 1995, Volume 2, Findings of the Landslide Investigation.* Geotechnical Engineering Office, Hong Kong, 68 p.

3.10 Geotechnical Engineering Office (1996b). *Report on the Shum Wan Road Landslide of 13 August 1995, Volume 2, Findings of the Landslide Investigation.* Geotechnical Engineering Office, Hong Kong, 51 p.

3.11 Geotechnical Engineering Office (1999). *Addendum Report on the Geology and Hydrogeology of Slope No. 11NW-A/C55, Ching Cheung Road.* Landslide Study Report LSR12/99, Geotechnical Engineering Office, Hong Kong, 57 p.

3.12 Geotechnical Engineering Office (2000a*). GEO Technical Guidance Note No. 2 (TGN 2) - Technical Recommendations arising from lessons learnt from landslides in 1997 and 1998.* Geotechnical Engineering Office, Hong Kong, 3 p.

3.13 Geotechnical Engineering Office (2000b). *GEO Technical Guidance Note No. 3 (TGN 3) Use of downhole geophysical methods in identification of weak layers in the ground.* Geotechnical Engineering Office, Hong Kong, 6 p.

3.14 Kirk, P.A., Campbell, S.D.G., Fletcher, C.J.N. & Merriman, R.J. (1997). The significance of primary volcanic fabrics and clay distribution in landslides in Hong Kong. *Journal of the Geological Society of London*, vol. 154, pp 1009-1020.

3.15 Knill, J.L. (1996). *Report on the Fei Tsui Road Landslide of 13 August 1995, Volume 1, Independent Review of the Investigation by the Geotechnical Engineering Office*. Geotechnical Engineering Office, Hong Kong, 13 p.

3.16 Lau, K.C. & Franks, C.A.M. (2000). *Phase 3 Site Characterisation Study – Stage 4: Evaluation of Downhole Geophysical Methods for Ground Investigation at the Field Trial Sites.* Technical Note No. TN 6/2000, Geotechnical Engineering Office, Hong Kong, 114 p.

3.17 Parry, S, Campbell, S.D.G. & Fletcher, C.J.N. (2000). Kaolin in Hong Kong saprolites – genesis and distribution. *Proceedings of the Conference on Engineering Geology HK 2000*, The Institution of Mining and Metallurgy – Hong Kong Branch, Hong Kong, pp 63-70.

4. DEFINITIONS

4.1 Volcanic rock is used here to include tuff, tuffite and lava of any composition.

4.2 Granitic rock is used here to include granite, granodiorite, syenite and monzonite, and finer-grained intrusive equivalents of all of these.

4.3 Eutaxitic is a descriptive term for foliation within pyroclastic rocks resulting in a streaked or banded appearance, and is due to pumice or other material being stretched out whilst still in a hot viscous state, and subsequently preserved by welding.

4.4 Saprolite is a term for soil derived from in situ rock weathering that retains evidence of the original rock texture, fabric and structure.

5. TECHNICAL RECOMMENDATIONS

5.1 In assessing the stability of a cut slope in volcanic or granitic rock, attention should be given to establishing whether any of the following geological features are present, and if so, whether they may adversely affect slope stability:

(i) laterally persistent (e.g.> 4 m) weak silt- and clay-rich layers [Note (1)], within the rock mass, regardless of thickness,

(ii) completely and highly decomposed rock (Grades V and IV) forming planar layers that sit on slightly and moderately decomposed rock (Grades II and III), and which dip directly, or obliquely outwards from slope faces [Note (2)], and

(iii) persistent (e.g.> 4 m), planar, steep joint sets and other geological contacts (e.g. dykes, faults etc.) that could form release surfaces.

5.2 The following additional ground conditions are often indicative of the presence of geological features listed in 5.1 and should also be checked:

(i) stratification dipping out of the slope (e.g. as indicated by eutaxitic foliation in some fine ash tuffs),

(ii) zones of continuous seepage, and

(iii) clusters of previous slope failures.

5.3 In site investigation, the following items are recommended to facilitate the identification of geological features that may be adverse to slope stability:

(i) The desk study should establish the history of any past failures (including the

mechanism and type of failure) and continuous seepage, and, where site formation photographs are available, the presence of significant geological features.

(ii) The engineering geological mapping should establish whether the orientation of bedding, bedding-parallel fabrics (e.g. eutaxitic foliation [Note (3)]) or laterally continuous discontinuities (e.g. sheeting joints) are adversely oriented, and identify any weak silt- and clay-rich layers, especially within adversely-oriented persistent discontinuities or along the weathering front (i.e. the boundary below which rock predominates in a partially weathered rock mass profile). Such adversely oriented weak layers may also occur in local depressions in the weathering front, caused for example by zones of faulting, discontinuities with close spacing, and subvertical eutaxitic foliation. Evidence of previous movement, especially that associated with any weak layers, should be noted, and could include:

(a) slickensiding, particularly within silt and clay-rich layers,

(b) brecciation and shear deformation of silt and clay-rich layers, and

(c) tension cracks and infilled tension cracks, possibly controlled by subvertical joints and particularly where associated with adversely oriented weak layers.

Zones of continuous seepage, especially where associated with silt- and clay-rich layers, should also be mapped.

(iii) During the initial phase of ground investigation, emphasis should be directed to developing a representative geological and hydrogeological model rather than testing. The ground investigation should focus on examining and logging the saprolite profile in detail, with emphasis placed on identifying the presence of adversely-oriented, weak silt- and clay-rich layers, especially in the vicinity of the weathering front, regardless or not whether these layers daylight in the slope under investigation. The ground investigation should also identify any such features within the rock mass where they may influence slope stability.

Suitable techniques for detailed examination of the saprolite profile should include:

(a) full-face mapping and logging of cut slopes, after stripping of surface cover, and adjacent exposures,

(b) excavation and logging of trial pits, and

(c) logging of drillholes.

Suitable techniques for detailed examination of the saprolite profile may also include:

(d) excavation of trenches or adits,

(e) continuous sampling in drillholes using triple tube core barrels with air-foam as the flushing medium, and

(f) downhole geophysical logging Note (4) and other downhole techniques, including borehole televiewer and impression packer.

6. ANNEX

6.1 TGN4 A1 - Explanatory Notes.

(R K S Chan)
Head, Geotechnical Engineering Office

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EXPLANATORY NOTES

(1) Weak silt- and clay-rich layers predominantly comprise white to buff kaolin, but may contain other materials, most notably dark brown manganiferous and iron oxides.

(2) At the Fei Tsui Road landslide site, the rock type was a eutaxitic fine-ash crystal tuff. The investigation of the Fei Tsui Road landslide (GEO, 1996a) highlighted various geological features in this rock type that influence the stability of cut slopes. The recognition of these geological features during site investigation at other cut slopes in similar rock types should raise awareness of the potential for a slope failure in similar circumstances to those pertaining at the Fei Tsui Road site.

(3) Eutaxitic foliation could provide an indication of the orientation of potential bedding plane structures in volcanic rocks.

(4) Technical guidelines on the use of downhole geophysical investigation techniques in the identification of weak layers are given in TGN 3.

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