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

GEO Technical Guidance Note No. 26 (TGN 26)
Supplementary Guidelines for Foundation Design in Areas Underlain by Marble and Marble-bearing Rocks

1. SCOPE

1.1 This Technical Guidance Note (TGN) provides supplementary technical guidelines for foundation design in areas underlain by marble and marble-bearing rocks. This TGN is intended to supplement the guidance given in the Environment, Transport and Works Bureau Technical Circular (ETWB TC) No. 4/2004 (ETWB, 2004) and the relevant Practice Note for Authorized Persons and Registered Structural Engineers (PNAP) No. 161 (BD, 1993).

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

2. TECHNICAL POLICY

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

3. RELATED DOCUMENTS

3.1 BD (1993). *Development in the Area Numbers 2 & 4 of Scheduled Area (Practice Note for Authorized Persons and Registered Structural Engineers No. 161)*. Buildings Department, Hong Kong, 8 p.

3.2 Chan, Y.C. (1994). *Classification and Zoning of Marble Sites (GEO Report No. 29)*. Geotechnical Engineering Office, Hong Kong, 37 p.

3.3 Chan, Y.C. (1996). Foundations in karst marble in Hong Kong. *Proceedings of the Twelfth Southeast Asian Conference on Geotechnical Engineering and Foundations*, Kuala Lumpur, Volume II, pp 169-199.

3.4 Darigo, N.J. (1990). Marble-bearing Jurassic volcanics of the western New Territories, Hong Kong. *Proceedings of the Conference on Karst Geology in Hong Kong*, Geological Society of Hong Kong, pp 61-72.

3.5 ETWB (2004). *Checking of Foundation Works in the Scheduled Areas of Northwest New Territories and Ma On Shan and the Designated Area of Northshore Lantau (Environment, Transport & Works Bureau Technical Circular No. 4/2004).* Environment, Transport & Works Bureau, Government Secretariat, Hong Kong, 15 p.

3.6 Frost, D.V. (1992). *Geology of Yuen Long (Hong Kong Geological Survey Sheet Report No. 1).* Geotechnical Engineering Office, Civil Engineering Department, 69 p.

3.7 Lai, K.W., Chan, H.H.K., Choy, C.S.M. & Tsang, A.L.Y. (2004). The characteristics of marble clast-bearing volcanic rock and its influence on foundation in Hong Kong. *Proceedings of the Conference on Foundation Practice in Hong Kong*, Centre for Research and Professional Development, Hong Kong, pp E1-E10.

3.8 Meigh, A.C. (1991). *General Report on Foundation in Areas Underlain by Marble and Associated Rock (Technical Note No. TN 3/91)*. Geotechnical Engineering Office, Hong Kong, 193 p.

4. BACKGROUND

4.1 ETWB TC No. 4/2004 and PNAP No. 161 require submission of design and construction details of all permanent foundation works to GEO for developments within the Scheduled Areas of the Northwest New Territories and Ma On Shan (Scheduled Area Nos. 2 and 4) where marble is known to exist. They give specific guidance on the planning and execution of ground investigation, design and construction of foundation works within the Scheduled Areas. This TGN provides supplementary technical guidance that aims at clarifying some design principles and requirements for foundations in areas underlain by marble and marble-bearing rocks.

4.2 Chan (1996) gives a discourse on foundation design for marble area.

5. SUPPLEMENTARY TECHNICAL GUIDELINES

5.1 MARBLE-BEARING ROCKS IN SCHEDULED AREA NO. 2

Scheduled Area No. 2 covers a large area where complex geology and marble-bearing rocks of the Yuen Long Formation and Tuen Mun Formation can be expected. The marble in the Tin Shui Wai Member of the Tuen Mun Formation exists as clasts in the volcaniclastic rocks (Frost, 1992; Lai et al, 2004). The marble clasts are generally not interconnected and dissolution of the marble clasts is localised, typically leading to honeycomb weathering of the rock. They do not usually develop into the karst features that are common in marble of the Yuen Long Formation. Nevertheless, adequate site investigations should be carried out to confirm the type of marble-bearing rock. The bearing capacity of the rock mass should be assessed, taking into account the possible honeycomb structure and solution features. While large cavities are rare in the volcaniclastic rocks, there are a few cases (Frost, 1992; Darigo, 1990) where relatively large cavities were encountered, which could have geotechnical significance to the design of foundations.

5.2 DEPTH OF EXPLORATORY DRILLHOLES

ETWB TC 4/2004 and PNAP 161 recommend carrying out exploratory drillholes to penetrate 20 m into sound marble as a minimum requirement when marble is encountered. In the context of determining the founding level of foundations bearing on marble, the sound marble can be taken as marble that has not been or is only slightly affected by dissolution, such as rock with Marble Class I or II (Chan, 1994).

5.3 FOUNDATIONS BEARING ON SOILS

5.3.1 For foundations bearing on soils, such as shallow footings or friction piles, the usual design practice is to limit the increase of vertical effective stress at the marble surface to an insignificant value, so as to prevent the collapse of any cavities in the rock due to the imposition of foundation load. The following limits on the increase of vertical effective stress are considered acceptable:

Site Classification[(1)]	Limits on increase of vertical effective stress at marble surface
A	Design controlled by settlement in soil stratum
B	5 – 10 %
C	3 – 5 %
D	< 3 %

Note: (1) Site classification is based on Chan (1994).
(2) Limits on increase of vertical effective stress are based on Meigh (1991).

For such a design approach, it is not necessary to carry out extensive ground investigation at close spacings to establish the karst dissolution features to a high resolution, unless substantial and severe karst dissolution features exist beneath the site that would be detrimental to the stability of the foundation. Some deep drillholes penetrating the marble bedrock shall be carried out to determine the likely extent of the karst dissolution features and the thickness of the overburden.

5.3.2 Other design requirements, such as bearing capacity and settlement of the foundation within the soil stratum, should be checked to ensure the satisfactory performance of the foundation.

5.3.3 Alternatively, the allowable increase of vertical effective stress can be determined by a rational design approach to demonstrate that the deformation of the marble rock and the infilled materials within cavities would not adversely affect the performance of the foundation.

5.4 FOUNDATIONS BEARING ON MARBLE BEDROCK

5.4.1 Bored pile foundations are usually designed to found on marble bedrock. The bedrock within the zone of influence of the foundation load should be of sound marble, which has not been or is only slightly affected by dissolution, such as rock mass with Marble Class I or II (Chan, 1994). Furthermore, no cavities should exist within the zone below the pile base to a depth equal to the diameter of the pile base. Other design aspects, which are applicable to foundations bearing on rock, such as overlapping of bearing stresses from adjacent piles and effect of highly undulating rock profile, should also be considered.

5.4.2 Driven piles are commonly designed to be driven to sound marble, e.g. rock mass with Marble Class I or II. Despite the requirement of hard driving, there are chances that the driven piles can be affected by karst features beneath the pile toe or damaged sustained during driving. A pile redundancy is provided for these uncertainties. Preboring may be used in case the piles have to penetrate overhangs or roofs to install piles at greater depth. In such circumstances, the pile redundancy can be adjusted accordingly.

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