


Development in the Area Numbers 2 & 4 of Scheduled Areas

The Designated Area of the North-western New Territories previously referred to in PNAP 129 and 134, and the Designated Area of Ma On Shan previously referred to in PNAP 136 are now, by virtue of the Buildings (Amendment) Ordinance 1990 & 1993, defined as Area Numbers 2 & 4 respectively of the Scheduled Areas in the Fifth Schedule of the Buildings Ordinance. The plans illustrating the exact extent of these areas are on display in the Buildings Department and in the Geotechnical Information Unit of the Civil Engineering Library. Location maps of these areas are attached for information.



2. This practice note describes geotechnical control measures in respect of building works in Area Numbers 2 & 4 of the Scheduled Areas (these Areas). It incorporates the contents of and supersedes PNAP 129, 134 and 136 and applies to submissions relating to ground investigation, foundation design and construction in these Areas, and to any groundwater pumping proposed in the Area Number 2 of the Scheduled Areas. It is complementary to PNAP 66 : Pile Foundations. The recommendations are based on practice developed since the discovery of the cavity problems and have been accepted by the profession.

3. The geology of these Areas comprises superficial deposits overlying metamorphosed sedimentary strata (siltstones, sandstones and marble) as well as igneous rocks. The marble usually has a karstic upper surface with solution features. Large cavities occur within the marble in some locations. The planning, design and construction of works which involve ground investigations, excavations, foundations or groundwater pumping may encounter significant difficulties as a result of these ground conditions.



Ground Investigation

4. Ground investigation in these Areas is within the definition of building works. Plans of any proposed ground investigation in these Areas are prescribed plans under Building (Administration) Regulation 8(1)(1) and must therefore be submitted for approval under the Buildings Ordinance.

5. Authorized persons (APs) and registered structural engineers (RSEs) are advised to ensure that ground investigation works are carried out to a high standard and are properly supervised. Guidance on ground investigation may be obtained from GEOGUIDE 2 : Guide to Site Investigation. It is advisable to employ competent contractors with a proven reputation who are capable of producing high quality work.

6. A suitably qualified and experienced engineer or engineering geologist should be employed in the planning and direction of the investigation and in the assessment and interpretation of its results. This person should have qualifications and experience in accordance with the guidance set out in Section 15.2 of GEOGUIDE 2.

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7. The field aspects of the ground investigation should be supervised by a suitably qualified and experienced engineer or engineering geologist, assisted by trained and experienced technical personnel. The qualifications and experience of the supervising engineer or engineering geologist and the technical personnel, and their responsibilities, should be in accordance with Sections 15.3 and 15.4 of GEOGUIDE 2. The engineer or engineering geologist should be required full-time on site whenever boreholes are sunk in an area underlain by marble. The cores recovered should be examined and properly logged by an experienced engineering geologist or geologist. Guidance on this aspect can be found in GEOGUIDE 3: Guide to Rock and Soil Description. Attention should be given to logging the location and size of the cavities, the nature of the cavity wall and the infill, together with rock discontinuities. Fracture indices including Total Core Recovery, Solid Core Recovery, Rock Quality Designation and Fracture Index should also be shown on the drill logs.

8. In these ground conditions, a ground investigation is best carried out in stages. It must be adequate to ascertain whether marble with cavities exists beneath the site, and allow an assessment of whether the cavities will affect the proposed development. Some deep drillholes will be required for this purpose. Cavities in marble, and related geological structures, may follow certain trends, and inclined boreholes may provide useful information if the dominant trend is vertical or near vertical. Geophysical survey may also provide additional information between drillholes. All drillholes should be grouted on completion.

9. It is advisable to carry out the initial stages of the ground investigation prior to the finalization of general building plans for the site because, in certain circumstances, adjustments to the locations of certain structures may be the most economical means of dealing with serious problems posed by cavities.

10. The depths of drillholes should relate to the depth of marble bedrock and the magnitude of the load to be applied by the structure. If marble is encountered, a minimum penetration of 20 m into sound marble rock is recommended in order to reduce the risk of existing cavities not being identified. Where cavities are encountered in the hole being drilled or in adjacent drillholes, increased penetration is necessary. The use of water as a flushing medium should be carefully controlled as there have been cases where sinkholes were induced by excessive use of flushing water. High quality core samples of the cavity infill can be obtained by using triple-tube core-barrels with air foam as the flushing medium. The intensity and depth of drillholes for each site will be governed by the nature of the structures proposed, the foundation loading and the ground conditions encountered.

11. Further investigation will normally be required once the layout of the development and the locations of piles have been decided. Some drillholes at the edges of the main piled foundation area may be required, since cavities at the edges are likely to be more detrimental than cavities at the inner part of the foundation area itself.

12. Discussion with the relevant district Chief Geotechnical Engineer of the Geotechnical Engineering Office before a ground investigation proposal is finalized may allow the optimum drillhole layout to be adopted and could expedite approvals of foundation plans. With regard to the requirements of Building (Administration) Regulation 20, at least two weeks prior notification of the intention to commence ground investigation work in the Area should be given to the relevant district Chief Geotechnical Engineer.

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13. Pending substantial completion of the building works, all cores and samples should be retained on site in good condition for inspection by the staff of the Buildings Department and the Geotechnical Engineering Office.

Foundation Design

14. Driven or machine-bored piles will usually provide the most suitable foundation for heavy structures on sites underlain by marble. Hand-dug caissons require dewatering, which might be difficult and could induce the formation of sinkholes. PNAP 158 also restricts the use of hand-dug caissons.

15. When driven piles are to be used, these should be of a suitably heavy section to withstand hard driving and with modified or strengthened tips. The modified section should be such as to allow the piles to be driven through and beyond any cover or rock bridging over shallow cavities or thin overhangs, and to prevent the piles deflecting where the marble surface is inclined. Pre-drilling may be necessary when very deep rock surfaces are expected or when piles have to penetrate thick karst zones. As it is not possible to determine the exact extent and configuration of subsurface cavities/overhang under each pile, the pile layout cannot be adjusted to suit all these features. It is, therefore, necessary to increase the number of piles used above the minimum so that, where cavities lead to local lack of support, the spare piles can then carry the redistributed load without being overstressed. It is necessary to consider this in the pile cap design.

16. When high capacity bored piles or barrettes are proposed, the effect of cavities below both the plan position of each pile or barrette and the surrounding area should be considered in the choice of founding level and allowable bearing capacity. Adequate drillholes should be sunk and, where appropriate, probing should be carried out to detect the presence of cavities, if any, within the zone significantly stressed by the piles.

Supporting Documentation to Accompany Foundation Plans

17. The following documentation is prescribed under Building (Administration) Regulation 8(1)(d) to accompany foundation plans for building works in the Area :

- (a) an explanatory guide to the submission;
- (b) a report containing the results of a study including topography, geology, groundwater, surface water, site history, public utilities, drains and sewers and other services, and local geotechnical records;
- (c) a report containing the results of ground investigation including comprehensive details of equipment and procedures used;
- (d) a report containing the results of site monitoring of groundwater conditions;

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- (e) a report containing critical examination and interpretation of (b), (c) and (d) above, a schedule of the geotechnical design assumptions, discussion of anticipated geotechnical problems and containing geotechnical requirements for the design and construction of the foundation works including testing, inspecting and maintenance requirements;
- (f) design calculations for foundation works.

18. Submissions not in compliance with this requirement will be liable to be refused under Buildings Ordinance Section 16(1)(a) and 16(1)(i).

Foundation Construction

19. Where driven piles are used as foundations, the piling reports submitted to the Buildings Department shall include the complete blow count records throughout pile driving. These should be presented in the form of blows per 500 mm where driving is easy, reducing to blows per 100 mm where driving is hard. The blow count should also be plotted against depth of penetration for each pile, in terms of blows per 100 mm. It is suggested that the dividing point between 'easy' and 'hard' driving should be at 10 blows per 100 mm.

20. The deviation of each driven pile from its initial position should also be surveyed.

21. In karst areas, there is always the risk despite conservative design, that foundation problems might arise, e.g. buckling of piles during driving, and reactivation of sinkholes or collapse of cavities during piling or foundation construction. An AP or RSE should therefore review the ground conditions experienced during foundation construction. Pile driving and other foundation construction records should be assessed at close intervals and the necessity or otherwise of modifying the design should be considered.

22. Trial piling and instrumentation of piles may be necessary in karst areas. General guidance on proof tests on piles is given in PNAP 66. Other non-destructive tests may have to be carried out on piles which are suspected to have deflected/defects or have anomalies in pile driving records.

Requirement for Submission of a Performance Review

23. In respect of foundation works in the Area, a condition may be imposed under Buildings Ordinance Section 17(1)(6) to require a performance review of foundation construction to be submitted and found acceptable prior to consent to commencement of superstructure works. However, it is not intended to impose this condition on every site within the Area.

24. Where a performance review is required it should include a review of the ground conditions experienced during pile driving, pile installation or foundation construction, and an assessment of pile driving or construction records. The review should also contain the results and an assessment of the pile load tests and evidence to demonstrate that any consequential changes in the design have been undertaken and plans suitably amended and approved.

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25. Consent to commence superstructure works may be refused under Buildings Ordinance Section 16(3)(ba) if any required performance review fails to demonstrate that the foundation works have been adequately inspected and the construction records adequately assessed in the course of construction, or that any necessary changes in the design have been undertaken and plans suitably amended and approved.

Monitoring

26. An AP or RSE should arrange for settlement monitoring of any building founded on cavernous marble using precise levelling or other approved methods. Such monitoring should commence as soon as possible after the completion of foundation works, and this should be continued until issue of occupation permit. Readings should be taken at intervals sufficiently close to minimize scatter, with a frequency not less than monthly. The results, together with an assessment of these, should be submitted to the Buildings Department monthly. Any unusual or significant settlement should be brought to the attention of the Buildings Department immediately.

27. It should be noted that, where appropriate, the Geotechnical Engineering Office will take over and continue the monitoring for a period following the granting of an occupation permit.

28. APs or RSEs should note that buildings founded in weathered siltstones and sandstones above marble may also encounter difficulties. They are encouraged to monitor the settlements during the construction of these buildings and to bring any unusual settlements to the attention of the Buildings Department immediately.

Water Wells

29. Where water wells are proposed, application to the Building Authority for approval shall be accompanied by a submission demonstrating that groundwater extraction will not adversely affect the site and the surrounding areas.

30. As mentioned in paragraph 10 of PNAP 17, it has been agreed with the Water Authority that, within Yuen Long town in Area Number 2 of the Scheduled Areas, piped flushing water will normally be supplied. Within Ma On Shan in Area Number 4 of the Scheduled Area, facilities for piped flushing water have been provided.

Additional Information Available

31. A considerable amount of information exists on the geology of the Area. For the Area Number 2 of the Schedule Areas, twenty 1:5000 Geological Map sheets are available, together with an account of the geology as Hong Kong Geological Survey Sheet Report No. 1 - Geology of Yuen Long. These can be obtained (free of charge) from the Planning Division of the Geotechnical Engineering Office. For Scheduled Area 4, geological maps for the areas 7-NE-C and 7-NE-D are in preparation, together with a report on the geology.

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32. APs or RSEs may contact the Chief Geotechnical Engineer/Planning of the Geotechnical Engineering Office for the latest progress on the results of the geological survey.

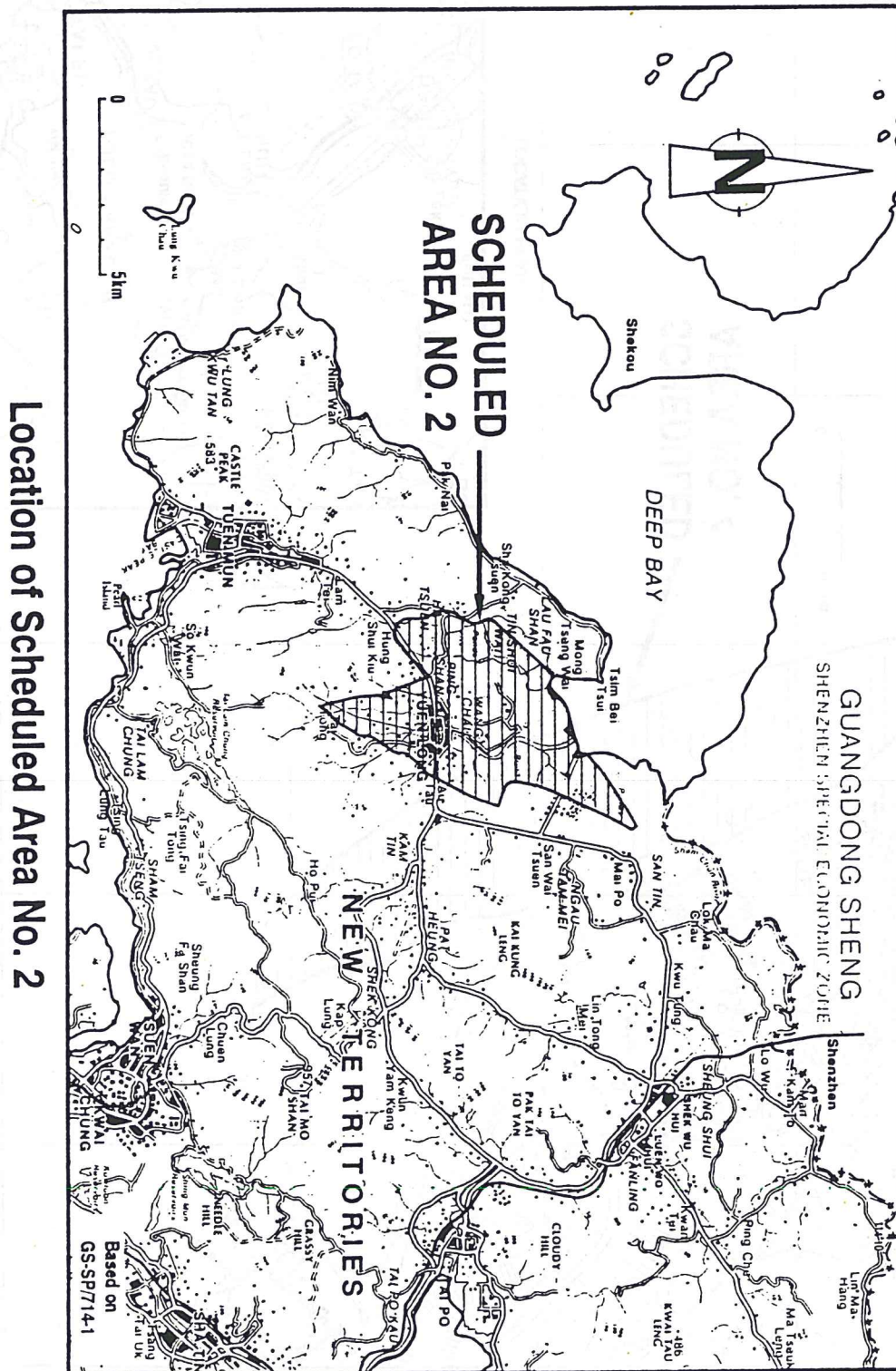


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Location of Scheduled Area No. 2



Location of Scheduled Area No. 4