APPENDIX A

MARINE GROUND INVESTIGATION IN DIFFICULT GROUND AREAS

APPENDIX A MARINE GROUND INVESTIGATION IN DIFFICULT GROUND AREAS

1. General

Difficult ground conditions generally refer to the existence of unfavourable subsoil strata on site. The presence of such conditions, if not properly handled, may lead to both problems at the construction stage and during the future use of seawalls, breakwaters and reclamation.

This Appendix provides suggested guidelines for marine ground investigation in areas with difficult ground conditions or likely to possess difficult ground conditions for seawalls, breakwaters and reclamation, based on the findings of the "Study on Coastal Subsoil Geotechnical Conditions" (CED, 2003).

The study identifies the following categories of difficult ground conditions in the Territory :

- Ground conditions that are difficult – These are difficult ground conditions with very thick marine deposit and/or extensive/thick interbedded soft alluvium below –35 mPD.
- Ground conditions that are likely to be difficult – These are ground conditions where marine deposit and/or soft alluvium are shown to exist in some borehole logs at about –35 mPD or below, or where the soil strata are variable but the available ground investigation information is not sufficient to lead to a definite conclusion.

2. Points of Exploration

2.1 Seawalls and Breakwaters

The spacing of the points of exploration, which may include a combination of boreholes and points of in-situ tests, may be taken as 75 m to 100 m if the structures are located in areas with thick, uniform marine or alluvial deposit layers. As an example of investigation arrangement, the points of exploration may include boreholes at 200 m spacing with cone penetration tests undertaken approximately halfway between boreholes. Additional cone penetration tests, about 5 to 10 % of the total number of boreholes, should be carried out adjacent to boreholes for calibrating the results of the cone penetration tests. Alternatively,

cone penetration tests undertaken halfway between the boreholes may be replaced by boreholes as appropriate to the site conditions.

If interbedded soft deposits are expected, the spacing of the points of exploration may be further reduced to 50 m or less in order to identify the locations and extents of the soft material. The investigation may include boreholes at 100 m spacing with cone penetration tests undertaken approximately halfway between boreholes. Similarly, additional cone penetration tests, about 5 to 10 % of the total number of boreholes, should be carried out adjacent to boreholes for calibrating the results of the cone penetration tests. Cone penetration tests undertaken halfway between the boreholes may be replaced by boreholes as appropriate to the site conditions.

At locations where highly variable soft deposits exist and where the soil strength is critical to the stability of structures, the double-hole sampling approach may be considered. A borehole is first sunk to obtain continuous profile of the soil strata for inspection and a second borehole adjacent to the first borehole is then sunk to undertake vane-shear tests at close intervals to ascertain the type, nature and strength of the soil. Attention should be paid to locate the second borehole at a sufficient distance away from the first borehole to avoid testing the disturbed ground caused by the drilling of the first borehole. Additional boreholes should be sunk if the collected information is not sufficient to ascertain the ground conditions.

2.2 Reclamation

The spacing of the points of exploration, which may include a combination of boreholes and points of in-situ tests, may be taken as 100 m, if interbedded soft deposits are expected in the subsoil profiles. As an example of investigation arrangement, the points of exploration may include boreholes at 200 m spacing with cone penetration tests undertaken approximately halfway between boreholes. Additional cone penetration tests, about 5 to 10 % of the total number of boreholes, should be carried out adjacent to boreholes for calibrating the results of the cone penetration tests. Alternatively, cone penetration tests undertaken halfway between the boreholes may be replaced by boreholes to suit the site conditions. Additional boreholes should be sunk if the collected information is not sufficient to ascertain the ground conditions.

3. Depth of penetration

The investigation should reach a depth of 5 m into the underlying Grade V weathered rock to determine the thickness of the marine and alluvial deposits, in order to allow an estimate of the stability and settlement of the structures and reclamation. In addition, 10% of the boreholes should be penetrated 5 m into Grade III rock to ascertain the location of firm bearing stratum.

4. In-situ Field Tests and Soil Sampling for Laboratory Testing

For in-situ testing and sampling, the following schedule should be applied :

(a) Vane shear tests and piston samples should be undertaken alternatively at 2 m intervals for clayey/silty soil. If double-hole sampling is carried out, vane shear tests should be continuously undertaken at 1 m intervals in the second borehole.

(b) Standard penetration tests (with liner samples) and U100 or Mazier samples should be undertaken at 2 m intervals for soils of sandy nature.

(c) For cone penetration tests, the measurement can be made at depth intervals of 0.2 m. The types of reading to be taken include the tip resistance and, if available, sleeve friction and pore pressure. Classification charts based on tip resistance, sleeve friction and/or pore pressure are available for estimation of soil types. For more accurate assessment of the soil properties, the test results should be calibrated with the information of an adjacent borehole.

The designer should prepare a schedule of laboratory testing for determining the grading, moisture content, density, strength deformation and consolidation characteristics of the soil. The following aspects should be noted :

(a) The laboratory testing conditions should resemble the field conditions in which the works or structures will be constructed and operate at various stages. The initial state of the samples as well as the state of the soils in the construction and operation should be clearly specified, taking into account the depth, soil permeability and future stress conditions.

(b) Unconsolidated and consolidated undrained triaxial tests should be carried out for soil samples taken along the potential slip surface of marine structures. However, the results of unconsolidated undrained tests may not be very reliable due to possible disturbance during

sampling. Hence, they should be used to supplement the in-situ strength obtained from the field tests. Consolidated undrained tests can simulate the long-term performance of the soil samples and their results can be used to assess the long-term stability of the structures. In view of the comparatively poor consolidation characteristics of clayey/silty soil, care should be exercised in adopting the consolidated undrained test results in the analysis of short-term stability. In-situ vane shear test results should be used for such analysis as far as possible.

(c) Oedometer tests should be carried out for soil left below the foundation of structures and reclamation. The number and interval of the samples to be tested should be determined according to the variability of the subsoil profiles, the layout of the foundation as well as the extent of dredging or soil treatment works.

5. Reference

CED (2003). Special Project Report No. SPR 1/2003 – Study on Coastal Subsoil Geotechnical Conditions. Civil Engineering Office, Civil Engineering Department, Hong Kong.