GUIDELINE

Professional Engineers Providing Geotechnical Engineering Services

1993

Published by
Association of Professional Engineers of Ontario

Revised 11/15/98

CONTENTS

GENERAL

Professional engineers in charge of geotechnical engineering works in either an investigative or a regulatory capacity should fulfil the requirements of this guideline.

This guideline outlines the extent of services provided and the general method to be followed, the types of reports and the normal range of the recommendations that may be included by the engineer originating the work. Engineers operating in a regulatory capacity should be familiar with these procedures in initiating a geotechnical investigation and in making an objective appraisal of submitted reports.

Geotechnical engineering embraces the knowledge of soil, rock, and other earth materials as applied to foundations, the behaviour of engineering structures, the assessment of natural land forms and the stability of natural and artificially created slopes. It includes aspects of soil mechanics, rock mechanics, groundwater conditions, foundation engineering, construction techniques as applied to building foundations, excavation methods, earth dams and embankments, foundations for pavements, floor slabs and other relevant aspects of construction works.

PHASES OF SERVICE

There are five phases of service normally required for most geotechnical engineering investigations and reports. The sixth phase of special services is occasionally required. These phases are:

Phase 1 - Preliminary Investigations

Phase 2 - Detailed Site Investigations

Phase 3 - Laboratory Testing of Samples

Phase 4 - Report and Recommendations

Phase 5 - Services During Construction

Phase 6 - Special Services

PHASE 1 - PRELIMINARY INVESTIGATIONS

In a project's conceptual planning stage, a preliminary investigation involving feasibility studies, assessment of the suitability of a site and appraisal of potential soil conditions for preliminary cost studies is carried out. It normally precedes detailed investigations.

1.1 Air Photo Interpretation

Where air photographs are available, the terrain of the site and surrounding area may be mapped to display some or all of:

- general drainage patterns;
- general slopes and ranges of gradients;
- bedrock outcroppings, where present;
- general surfacial soil types;
- poorly drained or swamp land;
- erosion features, and
- old or potential slope failure areas.

1.2 Literature Search

The geology of the area may be reviewed from known data, either to supplement the air photo interpretation, or to replace it where air photos are not available. All available physiographical data may be searched and previous site investigation data reviewed along with any available well records.

1.3 Ground Search

Following air photo interpretation and/or a literature search, a preliminary field search may be made to physically examine land forms, drainage, erosion cuts, etc. In addition, hand auger holes or rod soundings may be put down, or shallow test pits excavated to confirm the general surfacial soil, bedrock and groundwater conditions.

1.4 Preliminary Report

The total preliminary information available is provided in general terms. The data should be presented in a form that enables the client to assess the economic effect that the soil, bedrock and groundwater may have on the project's viability.

PHASE 2 - DETAILED SITE INVESTIGATION

Upon completion of the preliminary site investigation and the preparation of the client's general project planning, a more detailed site investigation should be carried out to provide data for final design plans. Generally, such work involves the physical sampling and testing of soils, groundwater and often bedrock, and normally precedes a laboratory testing program of selected field samples.

2.1 Field Drilling Exploration

The pattern of test-hole drilling should be the subject of discussion between the geotechnical engineer and the client or client's consulting design engineer. The nature of the project to be designed and the known physiography of the area usually dictate the location and spacing of the test holes, as well as the depth of the drilling program.

The drilling of the test holes should be carried out by an experienced drill crew using the type of equipment best suited for the terrain and soil condition anticipated. Holes may be advanced by wash boring (with or without driven casing), solid stem augers or hollow stem augers, by caisson auger drill or by excavating, as circumstances require. In all cases, the method by which the boring has been made must be clearly stated as part of the record of drilling. Such work should be performed under the direction in the field of a qualified experienced geotechnical engineer, or by a qualified experienced technician acting under direction of the geotechnical engineer.

2.2 Field Sampling

Exploration and field sampling work must be carried out in accordance with recognized practice, such as recommended in the Canadian Foundation Engineering Manual and by the American Society for Testing Materials (ASTM). The frequency and type of sampling operation may be varied by the requirements of the project, but should be under the control of the geotechnical engineer. (Normally, standard sampling is carried out at 0.75 metre intervals initially. Spacing is often increased to 1.5 m intervals below the 4.5 m or 6 m depth, if conditions warrant such increase.)

Types of samplers normally used include split spoons and thin-wall Shelby tubes. Other sampler types that may be required in certain types of soil are piston and Oesterberg samplers and foil samplers.

2.3 Field Testing

Field testing must be carried out in accordance with recognized practice such as recommended in the Canadian Foundation Engineering Manual and by ASTM, or in accordance with special instructions set out by the equipment manufacturers. Types of tests normally done include in-situ vane, standard penetration, dynamic cone penetration, pressure meter and pumping tests. Other tests, depending on soil conditions, may include static code penetrometer, flat dilatometer and various load tests.

Such tests must be utilized correctly and at the appropriate place in order to define the in-situ soils or bedrock parameters.

2.4 Groundwater Records

Fluctuations in the elevation of the groundwater occur over a period of time. It is considered good practice that the existing groundwater level be monitored by piezometers or other methods as a routine part of any investigation. The installation of such equipment should be in accordance with recognized standards and as directed by the qualified geotechnical engineer. Such installations usually require additional visits to the site to make field observations until conditions have reached equilibrium.

It is also essential that all seepage water encountered or initial water percolation into test holes be recorded as part of the drilling records at the time that the holes are drilled and sampled. Further, the rate of inflow and rise of water levels should be recorded at the time of the initial observations, to assess correctly the influence that the water condition may have on the design project as well as on construction procedures.

PHASE 3 - LABORATORY TESTING OF SAMPLES

It is normally a requirement that some samples obtained for the field investigation be tested in the laboratory to determine soil properties essential to the preparation of the soils' report. It is normally essential that the natural moisture content of samples be routinely determined at the time of the investigation. After completion of the laboratory testing program, the report and recommendations should be made based on the results obtained.

3.1 Classification Testing

Classification testing of samples is frequently carried out on disturbed soil samples, viz. driven split barrel samples, auger flight samples, clean-out tube samples, etc. Such classification tests as grain size analysis, Atterberg limits, moisture content determinations, soil pH, etc. must be carried out in accordance with recognized practice, such as that recommended by ASTM.

3.2 Strength Tests

Strength and consolidation tests should be carried out on undisturbed samples recovered from field sampling operations. Such tests may be carried out in a variety of ways, depending on the parameters required and the soil type being examined, but all must be in accordance with recognized practice, such as recommended in Canadian Standards, the National Building Code of Canada, and by the ASTM. Laboratory testing will be performed by trained and qualified technicians working under the control of an experienced geotechnical engineer.

Only such testing as is required to provide the data for proper analysis of the geotechnical problem should be carried out.

PHASE 4 - REPORT AND RECOMMENDATIONS

The geotechnical report should outline the investigation's terms of reference, summarize the findings of the field investigation and the supplementary laboratory testing, and present the conclusions and recommendations based on these findings. When construction proceeds, it is recommended that the geotechnical engineer be retained to provide services during construction. The services should be engaged by either the client or the design consultant.

4.1 Factual Data

The factual data comprises the terms of reference, the details of the field investigation, the results of the field testing, records of groundwater observations, laboratory test results, site plan and inferred soil stratigraphy, etc., and should be supplied as Part 1 of the report. This portion of the report should not include any conclusions derived from the factual data.

4.2 Report Recommendations

The report recommendation should be presented as Part 2 of the report, so that these recommendations may be excluded from the tendering documents if the user so desires.

Part 2 of the report should normally present recommendations to the user concerning the geotechnical conclusions provided. Such recommendations may cover a variety of activities, such as alternative founding depths/elevations with recommended design bearing values, caisson or pile design considerations, estimates of potential settlements, recommended safe slopes of banks or excavation walls, earth pressures for shoring design, dewatering requirements, soil stabilization, etc.

The recommendation should be made with due consideration to the construction proposed by the user, in order to provide the most economic viable alternatives available for consideration. Only in this way can the user obtain the true benefits available from a competently performed geotechnical report.

PHASE 5 - SERVICES DURING CONSTRUCTION

Further to the carrying out of a geotechnical investigation and report, various supplementary activities can be provided as part of the geotechnical engineer's work during the construction phase. Supplementary services that should be arranged by the user include:

5.1 Foundation Subgrade Inspection

Site inspection of the foundation-bearing medium during construction for footing excavations and caisson bases, etc. should be carried out under the supervision and control of the geotechnical engineer who prepared the original site investigation report.

The soils engineer should be given the opportunity to verify the conditions at the bottom of the excavated site as predicted and that no part of the excavation shows soil conditions that are substantially different than those predicted.

It is normally a requisite that such inspection certify that the specified bearing values have been achieved at the foundation level.

5.2 Pile Driving Inspection

During the driving of piles for the foundations, it is normally a requirement that an independent inspection be carried out by an inspector or technician under the supervision of the geotechnical engineer who carried out the site investigation report, to ensure that the piles have been driven to adequate penetration and set as required for the load design capacity of the pile. The pile driving records should include the final set, the founding elevation of the tip of the pile and the length of the pile in place, as well as the cut-off elevation of the pile. Geotechnical supervision should also be provided in the case of compacted concrete piles, drilled caissons, and vibroflotation and dynamic compaction operations, to ensure installations are in accordance with specifications.

5.3 Load-Test Supervision

Frequently load tests of piles or foundations must be carried out where such tests are a requirement of the local building by-law, or are otherwise deemed necessary. Such load testing should be carried out under the supervision of a technician working for the geotechnical engineer who carried out the original geotechnical investigation if the work is the responsibility of the user. The details of the load application and settlement under each increment of load must be recorded as the work proceeds. All such load tests should be carried out in accordance with recognized practice, such as that recommended by ASTM. Details of the tests should be presented in graphical form representing the load/time/settlement curves for the pile or footing tested; a report should be submitted providing details of the work and the results obtained.

5.4 Fill-Compaction Testing

Where filling work is a requirement of the contract, inspection and testing for approval of soils (site borrow material or granular fills) should be carried out by a qualified experienced soils technician under supervision of the geotechnical engineer. Where standards of compaction are a requirement for these fills, the physical testing of the fill material should also be carried out by a qualified and experienced soils technician under the supervision of the geotechnical engineer. As such testing is carried out, a report should be submitted to the user indicating acceptance or rejection of the work as it is performed.

5.5 Pavement Subgrade Testing

Road subgrades should be tested for design recommendations for the eventual pavement design, which should be based upon the nature and condition of the subgrade at the time of construction of the roadway. Such tests may involve laboratory testing of samples recovered from the site or in-situ testing of the subgrade in its prepared condition.

5.6 Slope Stability Monitoring

The installation and monitoring of slope indicators before, during and following construction of civil engineering works may be essential to the safety of the facility. Such work should be carried out only by qualified and experienced engineering technicians under the supervision of a geotechnical engineer.

5.7 Field Instrumentation - Settlement

Monitoring of instrumentation established during construction to check against settlement and stress changes is frequently a requirement of the geotechnical engineering services. Such work should only be carried out by qualified experienced technicians acting under the supervision of a geotechnical engineer.

5.8 Summary

In summary, the services of a professional geotechnical engineer are normally essential to the proper planning, design, erection and performance of structures. The report embodying the findings of the geotechnical engineer should be a necessary tool for the planner, designer and those contractors who specialize in dewatering, excavating, and foundations. It is thus recommended that the part of the report containing factual information be incorporated in the tendering documents.

PHASE 6 - SPECIAL SERVICES

Introduction

The following additional and special services are not provided in the foregoing sections. Depending on the project, the engineer may, where provided in the "Client/Engineer Agreement", perform the following services:

6.1 Special Specifications

The geotechnical engineer may provide special clauses to be included in the specifications where unusual soil, rock or groundwater conditions exist, where the design consultant requires special expertise.

The geotechnical engineer may review specification clauses as they relate to foundations, dewatering, earth works, etc., at the request of the design engineer.

6.2 Contract Drawings

The geotechnical engineer may provide special sketches for drainage provisions, special foundation measures, safe slopes and shoring requirements where so required.

The geotechnical engineer may review the foundation drawings for conformance to the geotechnical report recommendations if requested by the design engineer. Such a review is strongly recommended in the interests of the client and the design engineer.

6.3 Construction Site Meetings

The geotechnical engineer may be requested to attend special site meetings when problems of an unforeseen nature are encountered during the foundation or earth-works construction. Alternative or remedial proposals should be subject to review when they involve geotechnical consideration.

Prepared by:

Alex Kelly, P.Eng.
Mr. A.Bonca
Mr. D. Devenny
Murray Douglas, P.Eng.
Mr. K. Field
Paul Gleason, P.Eng.
Barry Hitchcock, P.Eng.
Victor Milligan, P.Eng.
Cam Mirza, P.Eng.
Ken Peaker, P.Eng.
Barry Walker, P.Eng.

on behalf of the Professional Practice Committee

Professional Engineers
Ontario

25 Sheppard Avenue West
Suite 1000
Toronto, Ontario
M2N 6S9

Tel: 416 224-1100 or 1-800-339-3716
Fax: 416 224-8168 or 1-800-268-0496

Enforcement Hotline: 416 224-9528 Ext. 444

Website: www.peo.on.ca