

RECOMMENDED PRACTICE
FOR
GEOTECHNICAL EXPLORATIONS AND REPORTS

by
The Structural Committee
of
The Foundation Performance Association
Houston, Texas

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PREFACE

This document has been developed by a group of Structural Engineers in southeast Texas with the goal to attain the geotechnical information they believe is necessary to adequately perform their structural designs. Their need for this document has been prompted by a large number of residential and light commercial foundation problems, some of which have been the subject of litigation. As a result, this document has been prepared specifically for the Structural Engineers' use. However, it is made freely available to the public through the Foundation Performance Association at www.foundationperformance.org so others may have access to the information and may adapt it to their work as they see fit. To ensure the document remains as current as possible, it is intended to be periodically updated under the same document number but with new revision numbers.

This document is a recommended practice only and is therefore intended to be neither comprehensive nor a substitute for engineering judgment or for local or standard codes and practices. The user should recognize that there is always the possibility this recommended practice might not be fully adaptable to the site being investigated and in those cases, the use of engineering judgment will be paramount. The intent of this document is to detail certain minimum requirements recommended for the geotechnical exploration and report, thereby ensuring that the Structural Engineer receives the information needed to perform an adequate foundation design. Thus, Geotechnical Engineers preparing proposals for a geotechnical exploration and report in accordance with this recommended practice must all follow certain minimum proposal requirements, which can help ensure a more uniform selection process during the procurement of their services.

In requiring the use of this recommended practice, the participating Structural Engineers understand that the request for the information specified herein would most likely increase the cost of the geotechnical work, since there is no intent to delete any of the work currently being executed in the geotechnical industry. However, they should also realize that this additional cost is necessary in order for them to better understand the soil characteristics of the site on which they plan to design a foundation.

When using this recommended practice, it is expected that the Client will provide a description of the foundations and structures proposed for the site. In addition, the Client should provide site plans that show the foundation outline(s), the foundation location(s), and the location and species of any trees that are planned to be removed and that have trunk diameters equal to or greater than 6 inches. If the lots are Wooded Lots, it is intended that the Client will provide a tree survey to the Geotechnical Engineer, showing the location, sizes, species and condition of the trees on each lot. The Client should not discount this requirement as something less than a necessity. Though not recognized locally to be a problem as recently as ten years ago, trees in this area are now known or at least suspected to be the main contributor in the majority of foundation problems in the local market. Therefore the recommendations addressing trees should not be taken lightly.

This recommended practice addresses a geotechnical report prepared specifically for foundation design and construction. In new subdivisions, the type of geotechnical report that addresses the streets and utilities is not acceptable as a substitute for the work specified herein. Preferably, the borings for a new subdivision should be taken after the streets are cut and the lot's fill is compacted. If however, the geotechnical exploration is made before the streets are cut, then it is the intent of this recommended practice that a separate exploration will later be procured in order to verify the required density, moisture content, and Atterberg limits for the fill material.

This recommended practice is written specifically for use in Houston and the general southeast area of Texas. Therefore, it should be used with caution if utilized elsewhere or if adapted for foundations other than those supporting residential or light commercial structures.

The main purpose of this recommended practice is to bring certain minimum requirements together into one document for local Structural Engineers to use in part or in whole, as they see fit. It is not meant to imply that problems will not occur if geotechnical explorations and reports comply in part or in whole with this recommended practice. The Foundation Performance Association and its members make no warranty regarding the recommendations contained herein and will not be liable for any damages, including consequential damages resulting from the use of this document.

DEFINITIONS

For the purpose of this document, the following definitions apply:

Builder – The general contractor responsible for performing the construction of the foundation, including the site work.

Client – The person or company using this recommended practice in the procurement of the geotechnical exploration and report.

Geotechnical Engineer – The engineer or engineering firm responsible for performing the geotechnical exploration and for providing a report of the results.

Structural Engineer – The engineer or engineering firm responsible for performing the structural design of the foundation.

Wooded Lot – A lot that contains at least one tree per thousand square feet (1 per 1000 SF) of lot area, with those trees having trunk diameters greater than or equal to 6 inches. Note that the trunk diameter measurement is intended to be made at approximately chest-height above the ground level. Although the proper term for tree stem diameter in arboriculture is “caliper”, that term is purposely not used herein because it is sometimes confused with “circumference” when measuring trees.

TABLE OF CONTENTS

- 1.0 MINIMUM CRITERIA**
 - 1.1 General**
 - 1.2 Site Exploration**
 - 1.2.1 Area Reconnaissance**
 - 1.2.2 Borings Quantities and Locations**
 - 1.2.3 Boring Depths**
 - 1.2.4 Sampling Frequency**
 - 1.2.5 Field Testing and Logging**
 - 1.3 Laboratory Testing**
 - 1.4 Reporting**
- 2.0 SPECIAL REQUIREMENTS**
 - 2.1 Slab-on-Grade Design Parameters**
 - 2.2 Drilled Piers Design Parameters**
 - 2.3 Suspended Slab Design Parameters**
 - 2.4 Select Fill Parameters**

1.0 MINIMUM CRITERIA

The following subsections outline the Geotechnical Engineer's minimum requirements in accordance with this recommended practice.

1.1 General

The Geotechnical Engineer should provide the Structural Engineer and Builder with sufficient information to enable them to: (a) design a structural foundation that is appropriate for the site conditions and is capable of adequately supporting the given building design loads, (b) provide a safe foundation design that meets local code and professional standards, and (c) carry out the site work and foundation construction in a safe and efficient manner. The Geotechnical Engineer should advise the Client if any requirements herein are in direct conflict with local codes and professional standards. In addition, the Geotechnical Engineer should carry out the work and prepare the report with the assumption that the Structural Engineer will never actually see the site for which the foundation will be designed.

1.2 Site Exploration

It is the Geotechnical Engineer's responsibility to investigate the site as required to comply with local codes, professional standards and the requirements of this recommended practice. In addition, the site exploration should include the following minimum criteria:

1.2.1 Area Reconnaissance

The Geotechnical Engineer should check the area of the building site and the area surrounding the site for any anomalies such as streams, ponds, fill, dumps, existing above-grade structures, escarpments, slopes, poor draining areas, seeps, outcrops, large trees, tree stumps, erosion, structures, roadways, railways, areas that appear to be wetlands, or anything else that will help the Builder and Structural Engineer understand the prior and present land use of and around the site. Representative color photos of the site should be recorded at the time of the site exploration and should be included in the final report. Where possible, the photos should include portions of the properties adjacent to the site. All anomalies, including trees and tree stumps with trunks equal to or greater than 12 inches diameter should be located on the boring plan. On Wooded Lots the Geotechnical Engineer should superimpose the data from the Client-supplied tree survey on his plans.

1.2.2 Boring Quantities and Locations

- a. For new residential subdivisions that are anticipated to have grade-supported foundations, at least one boring per 5 lots is recommended, but not less than one boring every two acres.
- b. For new residential subdivisions that are anticipated to have pier-supported foundations, at least one boring per lot is recommended.
- c. For individual residential lots or for properties with light-commercial buildings, one boring for every 2,500 square feet of building ground floor slab, but a minimum of two

- borings for the lot. The borings should be taken inside the projected building perimeter or as close as possible, if obstructions exist.
- d. For lots with predominately cohesive soils and with trees growing within 25 feet (even if located on adjacent property) of the proposed foundation, one boring should be taken within 10 feet, or as close as possible, of the largest tree having a trunk size equal to or greater than 12 inches diameter, even if this dictates an additional boring for the lot.
 - e. For additions of less than 1000 square feet, one boring is adequate, except that the boring should be taken within the proposed foundation area and the recommendations in Paragraph 1.2.2d are still applicable.

1.2.3 Boring Depths

Boring depths below are measured from the grade existing at the time of the site exploration.

- a. The minimum depth of every boring should be 20 feet. However, if the upper 10 feet are predominately cohesionless, then the minimum depth may be reduced to 15 feet.
- b. On Wooded Lots, or lots containing one or more trees with trunks equal to or greater than 12 inches diameter, and if these lots contain predominantly cohesive soils, borings should be a minimum of 25 feet depth.
- c. For sloped lots, where the proposed foundation is to be situated at a height H above the toe of an embankment (or estimated toe if submerged), if the horizontal distance from the foundation to the toe is less than $4H$, then the depth of borings recommended should be a minimum of $2H$.

1.2.4 Sampling Frequency

- a. Undisturbed samples should be taken at a minimum of 1-ft, 2-ft, 4-ft, 6-ft, 8-ft, 10-ft, 12-ft, 16-ft, 20-ft depths, and thereafter at a maximum of 5-ft intervals.
- b. If fill is known to have been placed on the site, sampling frequency should be increased to one sample per foot in the fill regions.
- c. A sample should also be taken at the bottom of the borehole.

1.2.5 Field Testing and Logging

- a. Each sample should be visually classified and logged during retrieval.
- b. Existence and depth of roots should be noted.
- c. Hand penetrometer testing should be done and reported on all cohesive samples.
- d. Standard penetration testing should be done and reported on all cohesionless samples.
- e. After the borehole is complete, measurements of the free water surface should be made and logged at completion of the borehole, and then again upon completion of the sitework, with that time interval being reported.

1.3 Laboratory Testing

The Geotechnical Engineer should perform sufficient laboratory testing to comply with the requirements of standard codes and local practices. However, the following laboratory testing is recommended as a minimum:

- a. Existence and depth of roots or root fibers should be observed and reported for each soil sample.
- b. Moisture contents should be performed on all samples retrieved.
- c. In cohesive soils, Atterberg testing should be performed on a minimum of one third of the samples retrieved, with emphasis towards the upper strata. Reports should include plastic limits, liquid limits, and plasticity indices.
- d. In cohesive soils, the percentage of clay (minus 2 microns) should be tested using a hydrometer.
- e. Cohesive samples at the recommended foundation bearing depths may be tested using the torvane testing device provided a baseline test is made using unconfined compression tests for comparison.
- f. For lots that have predominately cohesive soils, testing at each boring location should be done to determine soil suction. Soil suction tests should be conducted using the transistor psychrometer method, the filter paper method or other methods that give similarly reliable suction values. Where suction testing is recommended, it should be done at sample depths of 2-ft, 4-ft, 6-ft, 8-ft, 10-ft, 12-ft, 16-ft and 20-ft, but may be terminated earlier at the depth of constant suction, if determined.

1.4 Reporting

The Geotechnical Engineers may use their own standard reporting techniques. However, the final report should also contain the following where applicable:

- a. A statement confirming that the geotechnical exploration and report are in accordance with the requirements of this recommended practice. If any exceptions are taken, the report should note each exception and the reason for taking the exception.
- b. A general description of the site and surrounding properties, specifically addressing the anomalies as discussed in Paragraph 1.2.1.
- c. Color photos of the proposed building site and where possible, adjacent properties. A minimum of two photos is recommended, but the total number of photos should at least be equal to the total number of borings.
- d. A plot plan showing the approximate location of borings, tree trunks equal to or greater than 12 inches diameter and all anomalies as described in Paragraph 1.2.1. In the case of trees, include species where known, the condition of the tree if not healthy (i.e., “dying,” or “dead”) and show trunk diameters, measured at chest-height. If the site personnel are unable to identify the tree species, then an attempt should be made to classify them into categories that help the user to estimate the potential water usage of the tree. For example a tree could be classified as either a hardwood or pine. Alternatively, it could be classified either as a broadleaf or conifer.
- e. Boring logs that include all field and laboratory tests results, unless particular data is presented on other charts or tables.
- f. Descriptions and classification of the materials encountered.
- g. Elevation of the water table, if encountered. If no water was encountered, the report should state that the holes were “dry”.
- h. Provisions to mitigate the effects of expansive soils.
- i. Recommendations on earthwork stabilization requirements (including requirements for slope stability) needed to prepare the site before the foundation can be constructed.

- j. A discussion on foundation maintenance required in order to maintain the design.
- k. Combined (i.e., for the various borings) plots of moisture content profiles and plastic limit profiles vs. boring depths.
- l. Plots or tables showing the percentage of clay in cohesive samples as determined from hydrometer testing.
- m. A discussion of the degree of saturation or desiccation of the site as compared to the estimated equilibrium moisture contents of the samples. This can be presented graphically depending on the method used (e.g., a graph of moisture content minus plastic limit vs. depth).
- n. Combined (i.e., for the various borings) plots of suction values vs. boring depths.
- o. Interpreted output from the suction testing including the moisture active depth, the movement active depth, the edge moisture variation distance and the probable vertical movement, both up and down, of the ground surface.
- p. Specific discussion of trees to be removed before construction and of trees that are to remain after construction is complete, if known.

2.0 SPECIAL REQUIREMENTS

In addition to the general minimum criteria discussed above, there are some specific requirements that may be applicable to the Geotechnical Engineer, depending on the Client's needs. These requirements are as follows:

2.1 Slab-On-Grade Design Parameters

Regardless of the type of building foundation planned, if design recommendations are provided for slab-on-grade foundations, then the Geotechnical Engineer should provide recommendations as outlined in both (a) WRI's "Design of Slab-on-Ground Foundations," latest edition and (b) PTI's "Design and Construction of Post-Tensioned Slabs-On-Ground," latest edition.

2.2 Drilled Piers Design Parameters

If design recommendations are requested or made for drilled piers such as those recommended for slab-on-piers (at grade), suspended (structural) slabs, or structural floor-on-piers (i.e., with a crawl space) foundations, then the Geotechnical Engineer should provide recommendations for pier depth that takes into account possible upward and lateral movements as well as the normal downward movement due to gravity loads. Upward movement should be addressed if the soil is predominately cohesive. Lateral movement should be addressed if the site has pronounced slopes or if substantial fill is planned or has already been placed. In addition, the Geotechnical Engineer should also provide similar design recommendations as specified in Paragraph 2.1. Further, allowable design loads and recommended depths should be provided for both (a) drilled and under-reamed piers and (b) drilled straight shaft (skin friction) piers, in order to give the Client an opportunity to perform or obtain a cost/benefit study.

2.3 Suspended Slab Design Parameters

If design recommendations are requested or made for the entire slab to be suspended above the soil using a structural slab system, the report should prescribe the recommended void box height. In this case, the report should also advise the maximum possible heave the surface of the soil could experience if the site is exposed to an unlimited source of moisture.

2.4 Select Fill Parameters

On sites that require select fill be added to reduce the expansiveness of the in-situ soil, the Geotechnical Engineer should provide several options (e.g., different thickness of select fill/natural soil removal combinations versus potential heave/subsidence) that will allow the Client an opportunity to perform or obtain a cost/benefit analysis.
