# Geotechnical Manual


**MARCH 2017**

**ILLINOIS STATE TOLL HIGHWAY AUTHORITY**

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The Geotechnical Manual dated March 2017 replaces the previous version dated March 2016.

**Revision Summary**

- Article 1.1: Added title to Article 1.1: Purpose and Use to information under Introduction.
- Article 1.2: Added new article on abbreviations and acronyms.
- Article 1.3: Added new article on definitions.
- Article 2.1: Removed article.
- Article 2.2: Renumbered Article 2.2 to 2.1.
- Article 2.3: Renumbered Article 2.3 to 2.2.
- Article 3.6.3.2: Revised named of article to Retaining, Noise Abatment and Performance Based Walls. Revised article for minimum boring depth requirements for walls less than or equal to 20 feet. Revised article to include requirements for boring plans, subsurface data profile plot and soil borings for all wall types including performance based retaining walls and noise abatement walls.
- Article 3.9: Added new article for Soil Assessment for Slab Jacking.

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# SECTION 1.0 INTRODUCTION

## 1.1 Purpose and Use

This manual describes the requirements for the Geotechnical Engineer (GE) that will affect design and construction of various Illinois State Toll Highway Authority (Illinois Tollway) facilities. The work performed by the GE under these requirements shall consist of preparing geotechnical investigation programs; performing surface, subsurface, and laboratory investigations; carrying out engineering analyses; and providing recommendations for adequate geotechnical design and construction of various Illinois Tollway facilities. In addition to this manual, the "Geotechnical Manual" and the current All Geotechnical Manual Users (AGMU) Memoranda published by the Illinois Department of Transportation (IDOT) and guidelines provided by AASHTO are required to be followed in performing geotechnical investigations.

The subsurface investigations and engineering analyses shall consist of the following: reviewing and evaluating existing geological, geotechnical, and other relevant available data; performing site reconnaissance; carrying out subgrade surveys and foundation soil investigations through an adequate program of field sampling and testing and laboratory analyses; performing engineering analyses and evaluations; and submitting the results and recommendations in geotechnical reports. The subsurface investigations and engineering analyses shall be performed in compliance with the procedures outlined in this manual and with generally accepted principles of sound engineering practices.

Any necessary modifications and revisions required during the course of a specific design shall be supplied by the Illinois Tollway to the GE through the Design Section Engineer (Designer) or by the Illinois Tollway Project Manager if the GE is under contract directly with the Illinois Tollway.

All phases of geotechnical work shall be performed under the direct supervision of a Licensed Professional Engineer (PE) in the State of Illinois and have at least 10 years of experience in the field of geotechnical engineering. The GE shall be prequalified by IDOT in the project required category.

This version of the Geotechnical Manual supersedes all earlier manuals. The Designer and the GE are required to review and follow the guidelines outlined in this document.

## 1.2 Abbreviations and Acronyms

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| AGMU | All Geotechnical Manual Users |
| ASTM | American Society for Testing and Materials |
| CPT | Cone Penetration Testing |
| DCP | Dynamic Cone Penetrometer |
| Designer | Design Section Engineer |
| FVS | Field Vane Shear |
| GE | Geotechnical Engineer |

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|---|---|
| IDOT | Illinois Department of Transportation |
| Illinois Tollway | Ilinois State Toll Highway Authority |
| PE | Professional Engineer |
| RGR | Roadway Geotechnical Report |
| RQD | Rock Quality Designation |
| SCP | Static Cone Penetrometer |
| SGR | Structure Geotechnical Report |
| SPT | Standard Penetration Testing |
| TS&L | Type Size and Location |
| USDA | United States Department of Agriculture |

## 1.3 Definitions

Refer to the "Terms and Definitions" section of the latest edition of the "Design Section Engineer's Manual," which contains the definitions of frequently used terms as well as definitions with special or special meanings as it applies to Illinois Tollway work.

**NOTE:**
This manual follows the traditional definitions for **shall, should,** and **may**. **Shall** is used to mean something that is required or mandatory, while **should** is used to mean something that is recommended, but not mandatory and **may** is used to mean something that is optional and carriers no requirement or recommendation.

## SECTION 2.0 GENERAL CONSIDERATIONS

### 2.1 Project Organization and Procedures

The GE may provide services under a subconsultant agreement with the Designer or under direct contract with the Illinois Tollway. The GE may be hired directly by the Contractor for a performance based or a design-build project.

The GE shall furnish engineering services within the Design Section in accordance with the articles of this manual. Such services shall be performed in coordination with the Designer and/or the Illinois Tollway. All field explorations, laboratory testing, soil profile drawings and engineering reports shall be submitted to the Designer/Illinois Tollway for review. The Designer shall submit the GE work to the Illinois Tollway for their review when the work is not performed directly for the Illinois Tollway.

The Designer's or the Illinois Tollway's Project Managers shall issue instructions pertaining to the work and provide a direct contact with the GE during the course of the project. The GE shall assign a project manager who will be responsible for overall performance of work and serve as the direct contact between the Designer or Illinois Tollway and the GE. Project correspondence shall be accomplished through the Designer's Project Manager if work is done under a Designer contract or with Illinois Tollway’s Project Manager if work is done under a direct Illinois Tollway contract.

The GE shall coordinate work with the Designer/Illinois Tollway Project Manager. Any available existing geotechnical data shall be provided by the Illinois Tollway. Location data necessary for the subsurface investigation, proposed grade along the roadway centerline and/or baseline, design data necessary for evaluating the soil conditions and preparing geotechnical recommendations shall be provided to the GE by the Designer/Illinois Tollway.

Proposals submitted by the GE to the Designer shall be forwarded to the Illinois Tollway for review and approval.

### 2.2 Standards and References

The GE shall furnish services in accordance with the articles of this manual and the Illinois Tollway's policies and procedures. Where this manual does not address specific requirements, the GE's work shall be guided by the appropriate criteria established in the current editions of the following manuals and documents:

- IDOT “Geotechnical Manual” and AGMU Memoranda
- AASHTO “Manual on Subsurface Investigations”
- Illinois Tollway “Design Section Engineer’s Manual”
- Illinois Tollway “Structure Design Manual”
- “Illinois Tollway Supplemental Specifications to IDOT Standard Specifications”
- IDOT “Standard Specifications for Road and Bridge Construction”
- IDOT “Subgrade Stability Manual”

- IDOT “Bridge Design Manual”
- IDOT “Culvert Manual”
- “AASHTO LRFD Bridge Design Specifications, Customary U.S. Units”
- “AASHTO ASD Standard Specifications for Highway Bridges”

This manual does not address sampling or testing requirements of hazardous or special waste materials. The “Manual for Conducting Preliminary Environmental Site Assessments for Illinois Department of Transportation Highway Projects” contains information on subsurface investigation for some environmental purposes. Should the GE encounter potential soil or groundwater contamination, the GE shall immediately stop the work and notify the Designer/Illinois Tollway. Further work directions shall be discussed with the Designer/Illinois Tollway Project Manager.

## SECTION 3.0 GUIDELINES FOR FIELD INVESTIGATIONS

The field work shall be conducted in accordance with this Illinois Tollway Geotechnical Manual. The field engineers assigned by the GE for supervising the field investigations shall have more than two years of experience in geotechnical investigations. Drillers shall not be allowed to log and evaluate the subsurface conditions. Field investigations shall begin only after the proposed geotechnical investigation program has been reviewed and approved by the Designer and/or Illinois Tollway.

### 3.1 Geotechnical Investigation Program

The GE in coordination with the Designer and/or Illinois Tollway shall prepare a geotechnical proposal that includes a general description of proposed engineering works and estimated number of borings and termination depths, effort required to access boring locations, traffic control requirements, anticipated in-situ and laboratory tests, fees related to permits, insurance, access on private property, fees for site restoration, labor hours required to complete the proposed work, and schedule of completion.

The geotechnical investigation program, including boring locations on drawings showing the existing and proposed site conditions if available, types and estimated depths of samples, and laboratory testing to be performed shall be submitted for approval after the completion of the desk study and site visit. The geotechnical investigation program shall be adjusted to accommodate design changes and/or unexpected subsurface conditions. Major changes to the investigation program that may impact budget or schedule of completion shall be approved by the Illinois Tollway. Should a borehole be abandoned without the permission of the Designer/Illinois Tollway, or a boring not carried to the required depth, or should the GE fail to keep complete records of materials encountered or furnish the required samples and cores, then the GE shall make an additional boring at a location selected by the Designer/Illinois Tollway. No payment shall be made for either the abandoned hole or any samples or cores obtained from the abandoned hole.

### 3.2 Desk Study

A desk study shall be performed before any investigation program is started. The desk study shall include the review of geological setting, existing geotechnical boring and water well records, existing bridge drawings and foundation installation records. The GE shall evaluate for usefulness, the existing subsurface information and consider the information when planning and performing the field investigation, assigning laboratory testing, and performing engineering analyses. The use of previous data by others shall be at GE’s discretion. The GE shall notify the Designer and /or the Illinois Tollway regarding the usefulness of existing geotechnical data and document the decision. A staged approach consisting of two or more phases of field exploration may be developed to address special problem areas.

## 3.3 Site Visit

The GE shall visit the project site before preparing the geotechnical investigation program and mobilizing the field crew to the site. Ground surface features, potential construction limitations and impacts on nearby structures, evidence of distress or deformation in the existing pavements and foundations, and signs of approach settlement shall be examined during the site visit. The borings may be located in the Illinois Tollway median or shoulders, on slopes adjacent to roadways, within Illinois Tollway ramp enclosures, or in other areas where vehicular traffic is limited. During the field visit, the GE shall evaluate difficulties in successfully reaching and/or performing work at the site and report to the Designer/Illinois Tollway as necessary.

## 3.4 Permits and Utilities

The GE shall be responsible in identifying utilities in the area by contacting JULIE, DIGGER, Illinois Tollway Maintenance, and other agencies as necessary. Field crews shall maintain a safe working distance from both overhead and buried utilities. If practical and permitted, the power lines shall be de-energized and grounded or temporarily moved.

The GE shall be responsible for obtaining right-of-entry on private property, as well as necessary permits on public property. If right-of-entry is not granted, the Illinois Tollway and Designer will assist the GE to obtain the right-of-entry.

## 3.5 Methods and Procedures

The equipment used shall be suitable for determining boundaries and properties of soil and rock strata and groundwater conditions, as well as for obtaining samples for examination, field classification, and laboratory testing. It shall be the responsibility of the GE to determine the needs of each site and to mobilize the appropriate equipment required to perform the work.

The selection of the specific exploration methods to be used for a particular site investigation shall be decided by the GE. Soil sampling and rock coring shall conform to the following standards and procedures:

### 3.5.1 Soil Sampling

Split barrel samples shall be obtained in accordance with AASHTO T206 “Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils.” A representative, intact, specimen of each split-barrel sample shall be preserved in a 2-inch diameter, 8-ounce, screw-top, airtight clear glass jar. The samples shall be placed in the jars and sealed as soon as taken, and the jars shall be stored in properly labelled boxes. The jar labels shall show the project number, boring name and sample number, sampling interval from which sample was taken, the number of blows for each six inches of penetration, and the result of unconfined compressive strength tests. The samples shall be protected against freezing and the jars against breakage.

Hand auger, Geoprobe®, or other type of samples for which both the sample depth and soil bed thickness may be estimated with reasonable accuracy are allowed for subgrade borings or in locations of difficult access. Auger cutting samples shall be used only for sample identification or bulk samples. Soil samples obtained from hand augers and Geoprobe® samplers shall be preserved in similar type and size glass jars.

Three-inch diameter, thin-wall Shelby tube samples obtained, sealed, and transported following AASHTO T207, "Standard Method of Test for Thin-walled Tube Sampling of Soils," shall be acquired in deposits of soft (unconfined compressive strength less than 1.0-ton per square foot) and/or highly compressible soils in embankment areas, or where advanced strength and deformation laboratory testing is required.

Representative soil samples may be required for chemical and physical analyses associated with environmental studies. Samples shall be obtained using the technique and equipment specified by the US and Illinois Environmental Protection Agency's established guidelines and criteria. Soil sampling, classifications and testing for wetland mitigation shall be in accordance with Technical Report Number Y-87-1, Corps of Engineers Wetlands Delineation Manual prepared by the Environmental Laboratory of the US Department of the Army.

### 3.5.2 Bedrock Coring

Continuous core samples shall be obtained by means of a diamond drill and double tube core barrel, so as to yield continuous cores no less than 2 1/8" (NX size) diameter according to AASHTO T 225, "Standard Method of Test for Diamond Core Drilling for Site Investigation." Rock cores shall be placed in suitable wooden or heavy duty plastic boxes, so partitioned that the cores from each boring will be kept separate and the cores shall be properly placed in the order in which they were removed from the core barrel, and to show where portions, if any, were lost. Adjacent runs shall be separated by means of wood blocks, on which the elevation of the top and bottom of the run shall be clearly and permanently marked. The wooden core boxes shall have a cover hinged at one edge and fastened down securely at the other edge and shall be substantially made to withstand normal abuse in shipment. Core boxes shall be properly labeled showing the project number, boring name, core run number, and coring interval depths.

### 3.5.3 Pavement and Bridge Coring

Three-inch to four-inch diameter pavement cores shall be considered for pavement resurfacing, rehabilitation, reconstruction, or rubblization projects. Six-inch diameter core holes may be performed where bulk subbase samples or DCP testing of subbase and/or subgrade are required. The method of coring shall be such so as to produce an intact core sample. The core holes in HMA pavement shall be backfilled and patched with cold asphalt patch. Core holes in concrete pavement shall be patched with a rapid hardening cement R2 or better material according to Table 1 of ASTM C928, "Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs."

Bridge cores may be considered for bridge deck surveys and substructure evaluations. The Designer/Illinois Tollway shall confirm that taking bridge deck cores will not affect the structural integrity of the deck. Core holes in bridge structures shall be repaired with a rapid hardening cement R3 or better material according to Table 1 of ASTM C928.

3.5.4 Other In-situ Field Tests

If the site subsurface conditions and design requirements dictate, the following in-situ field tests may be proposed in addition to Standard Penetration Testing (SPT) for further advanced subsurface investigation.

**Single Ring and Double Ring Infiltrometer Test** – Single Ring Infiltrometer and Double Ring Infiltrometer tests may be performed to measure the infiltration rate of the underlying soil. Tests shall be performed in accordance with ASTM D5126, “Standard Guide for Comparison of Field Methods for Determining Hydraulic Conductivity in Vadose Zone” for Single Ring Infiltrometer testing and ASTM D3385, or “Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer” for Double Ring Infiltrometer testing.

**Dynamic and Static Cone Penetrometer Test** - Dynamic Cone Penetrometer (DCP) and Static Cone Penetrometer (SCP) tests may be performed to evaluate subbase and subgrade properties, to better delineate lateral and vertical extent of soil areas requiring improvement or stabilization, or in areas of difficult access in conjunction with hand auger probes. DCP and SCP equipment and testing procedures shall be according to IDOT “Geotechnical Manual” and “Subgrade Stability Manual.”

**Field Vane Shear Test** – Field Vane Shear (FVS) tests are recommended for determining the undrained shear strength of very soft to stiff, saturated cohesive soils. FVS testing provides refined undrained bearing capacity analysis and potential shaft squeeze evaluations. The test is not applicable for permeable soils that may drain at standard shearing rates. Thus, previous knowledge of the site soil profile is required before planning FVS tests. This test consists of advancing a four-bladed vane into cohesive soil to the desired depth and applying a measured torque at a constant rate until the soil fails in shear along a cylindrical surface. The torque measured at failure provides the undrained shear strength of the soil. A second test ran immediately after remolding at the same depth provides the remolded strength of the soil and thus information on soil sensitivity. Tests shall be performed in accordance with AASHTO T223, “Standard Method of Test for Field Vane Shear Test in Cohesive Soil.”

**Pressuremeter Test** - In-situ horizontal stresses, shear strength, bearing capacities, and settlement may be estimated using pressuremeter test results. The pressuremeter test results may also be used to obtain load transfer curves (p-y curves) for lateral load analyses. This test is performed with a cylindrical probe placed at the desired depth. Menard or TEXAM pressuremeters in predrilled holes may be used. Tests shall be performed in accordance with ASTM D4719, “Standard Test Method for Prebored Pressuremeter Testing in Soils.”

**Cone Penetrometer Test** – Cone Penetration Testing (CPT) is recommended for fast and cost effective characterization of subsurface soil conditions; evaluation of driven pile capacities; analysis of shallow foundation and embankment settlement magnitude and rate; and seismic site class determination by seismic shear wave measurement. This test is a quasi-static penetration test in which a cylindrical rod with a conical point is advanced through the soil at a constant rate and the resistance to penetration is measured. Tests shall be performed in accordance with ASTM D5778 - Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils (electro-piezocones).

The penetrometer data is plotted showing the tip stress, the friction resistance and the friction ratio (friction resistance divided by tip stress) vs. depth. Pore pressures may also be plotted with depth. The results shall also be presented in tabular form indicating the interpreted results of the raw data. The friction ratio plot maybe analyzed to determine soil type. Many correlations of the cone test results to other soil parameters have been made, and design methods are available for spread footings and piles. The penetrometer may be used in sands or clays, but not in rock or other extremely dense soils. Generally, soil samples are not obtained with soundings, so penetrometer exploration shall be augmented by SPT borings or other borings with soil samples taken.

The electro-piezocones may be used to measure the dissipation rate of the excessive pore water pressure. This type of test is useful for soils that are very sensitive to sampling techniques. Electro-piezocones may also be fitted with other instrumentation above the friction sleeve. The additional instrumentation may include geophones that may be used to measure shear wave velocities.

**Geophysical Testing Methods -** Geophysical testing methods are non-destructive testing procedures which provide general information on the general subsurface profile, depth to bedrock and water table, bedrock engineering properties, presence of karst features, extent of peat deposits, or presence of voids and buried utilities. Geophysical testing methods may also be used to evaluate existing bridge decks, foundations, and pavements. The specific application shall be proposed by the GE and approved by Designer/Illinois Tollway.

### 3.5.5 Backfilling Boreholes and Site Restoration

After samples, observations, and information have been obtained, the holes and excavated areas shall be backfilled according to the IDOT “Geotechnical Manual.” The GE shall remove all equipment, materials, and supplies and the site shall be restored to the satisfaction of the Illinois Tollway and/or the agency that has jurisdiction over the land.

### 3.5.6 Field Boring Logs and Sample Preservation

Soil sample jars and boxes, core boxes, and bulk samples shall be properly labeled with all pertinent identifying information for future storage purposes. Materials encountered in each boring shall be carefully examined and visually classified at the time of sampling, and a written record (field log) shall be prepared. Information and test data obtained and recorded during field exploration shall be incorporated in the final boring logs that the Designer shall incorporate in

the Pre-Final Design Phase (95%) submittal. Photographic records of bedrock and pavement cores shall be kept. A scale shall be included in each picture for size comparison.

The field engineer is responsible for checking clearance of boring locations of underground and overhead utilities, approving the traffic control set up, overseeing drilling operations including the health and safety procedures, and surveying as-drilled boring locations. The field engineer shall record drilling and coring rate changes, measure water table depth in boreholes, record SPT blow counts per 6 inches of split spoon penetration, test unconfined shear strength (Qu) of cohesive soils using the IDOT-modified Rimac machine and hand penetrometer, classify soils samples and collect representative samples for further examination and laboratory testing. If bedrock cores are obtained, the field engineer shall describe and classify them and measure recovery and Rock Quality Designation (RQD).

After completion of testing and 30 days after geotechnical report submittal, the soil samples and pavement and bridge cores may be discarded unless otherwise directed by the Illinois Tollway. If requested, rock cores shall be submitted to the Illinois Tollway for archival.

## 3.6 Geotechnical Investigation Program Guidelines

The location, type, spacing, and number of borings, as well as estimated termination depths shall be proposed by the GE for review and approval by the Designer/Illinois Tollway. The proposed boring program shall be in general accordance with IDOT and AASHTO guidelines and based on preliminary plan and profile drawings provided by Designer/Illinois Tollway.

Consideration shall be given to previously performed geotechnical explorations, which may have been conducted along all or part of the proposed project limits. New borings shall be considered especially for significant revisions in horizontal alignment, proposed profile grades, and/or structure locations. Boring programs for various structures may be combined to reduce drilling quantities.

Due to local topographic conditions and utilities, boring spacing and location requirements specified in this manual may not be feasible. In such cases, the GE shall use best judgment and locate the borings in the most appropriate location possible.

### 3.6.1 Subgrade Borings

Subgrade borings shall be drilled for mainline, cross road, interchange ramp, and parking area pavements.

In general, soil borings for mainline Illinois Tollway shall be made at 150 foot intervals alternating in direction of traffic. Borings for crossroads, interchange ramps, access roads, etc., shall be located to provide needed information but shall not be spaced greater than 300 feet apart. When an existing mainline or crossroad is to be widened, soil borings shall be made at 300 foot intervals for each widening side. Borings for widening shall be staggered between near shoulder and top of backslope in a cut section of the roadway. Borings in a fill section shall be staggered between the near shoulder and toe of the existing embankment. The borings shall

penetrate to a depth of at least 10 feet below the crown grade in cut sections, and to at least 10 feet deep or to 2/3 of the height of proposed embankments. If soft cohesive soils or peat are encountered, depth shall be increased as required to fully evaluate the stratum. Soils shall be continuously sampled with the 2-foot long split spoon sampler.

### 3.6.2 Stability Borings

Stability borings shall be made in areas where cut or fill heights greater than 15 feet are anticipated. These borings may be located along the right-of-way or outside the right-of-way (if possible) to obtain adequate subsurface conditions for proper slope stability analysis and to identify and analyze construction challenges.

In general, the stability boring spacing for roadway embankments shall be 200 feet. If variable conditions or weak and/or compressible soils (Qu less than 1.0 tsf and/or moisture contents higher than 25%) are anticipated, this spacing may be decreased to 100 feet. At least one boring shall be located at the point of maximum height of embankment. The boring depth measured from the existing grades elevations shall be approximately two to four times the height of the proposed embankment, depending on the width of the proposed roadway or to bedrock if encountered above that depth. The depth may be decreased to approximately the height of the embankment if suitable bearing soils (Qu equal or greater than 2 tsf) are encountered. The soil shall be sampled with an 18-inch long split spoon sampler at 2.5 foot intervals.

In general, the stability boring spacing for roadway cuts shall be about 100 feet. At least one boring shall be located at the maximum depth of the proposed cut. The boring depth shall be about twice the depth of the excavation or to top of bedrock, whichever is encountered first. The soil shall be continuously sampled with a 2-foot long split spoon sampler.

### 3.6.3 Structure Borings

#### 3.6.3.1 Bridges

As a minimum, one boring at each pier, abutment and approach span bent with alternate borings on opposite sides of the centerline of each structure shall be performed. Thus, dual structures would require four abutment borings plus multiple pier borings.

The following number of borings is recommended for single structures. When the proposed bridge width is greater than 76 feet, two borings shall be made for each substructure unit. When an existing bridge is to be widened on one side, one boring at each substructure unit shall be made. When an existing bridge is to be widened on both sides, it shall be considered as a dual structure when the width of the existing bridge is greater than 76 feet. When the width of the existing bridge is less than 76 feet, the type of existing foundation shall govern: drill two borings where spread footings are present and one boring where piles or drilled shafts are present. Perform one boring at the outer end of each wingwall longer than 20 feet.

When an existing bridge structure is to be reconstructed, coordinate with the Designer and the Illinois Tollway to determine if additional subsurface data is required.

Unless rock is encountered first, bridge borings shall be drilled to a minimum depth that will provide 90 tons bearing for a 12-inch diameter metal shell pile. Field bearing estimates shall start at the natural ground elevation and be performed using to the IDOT “Geotechnical Manual” empirical charts.

Sampling interval of the borings shall be 2.5 feet to a depth of 30 feet below footing level, and at 5.0 feet below that depth. Additional split-spoon samples may be taken as needed. When auger refusal is encountered during drilling, a minimum of 10 feet of rock core shall be obtained in at least half of the borings to ensure the exploration has not been terminated on a boulder and to determine the physical characteristics of rock. Where bedrock is encountered above, at, or within 20 feet below the proposed footing elevation, a minimum of five feet of sound bedrock (RQD> 75%) shall be cored. For foundations supported on drilled shafts socketed in bedrock or on top of bedrock longer rock cores shall be considered.

For major river bridges and long span structures, the GE shall work with the Illinois Tollway Project Manager to create a project specific geotechnical investigation program.

3.6.3.2 Retaining, Noise Abatement and Performance Based Walls

For retaining walls less than or equal to 20 feet in height, drill one boring at each wall end and space the remaining borings at a maximum interval of 75 feet. Drill at each end of a wall if its length is less than 75 feet. For wall height greater than 20 feet, use a maximum boring spacing of 50 feet.

For retaining walls less than or equal to 20 feet in height, borings shall extend to a depth of twice the total height of wall below footing level, but not less than 20 feet deep. Borings shall be extended at least 10 feet below soils having blow counts less than 10 blows per foot and/or Qu less than 1.0 tsf. Sampling shall be at 2.5 foot intervals. For walls over 20 feet in height, borings shall be continued to sufficient depths to fully determine the soil profile and estimates of pile or drilled shaft lengths may be made if necessary. If bedrock is encountered within the proposed termination depth of the boring, at least half of the borings shall be cored to a depth of 10 feet or more into bedrock.

Noise abatement wall borings shall be spaced at 100 foot intervals or less if variable ground conditions are anticipated. The borings shall be terminated at depths of twice the noise abatement wall height and sampled at 2.5 foot intervals. If bedrock lies above the proposed boring termination depth, core the bedrock for a minimum depth of 5.0 feet in each boring.

A boring plan, subsurface data profile plot and soil borings shall be included in the geotechnical report for all wall types.

For performance based retaining and noise abatement walls, the requirements listed above shall also apply.

3.6.3.3 Culverts

For culverts shorter than 75 feet, drill one boring near the proposed ends. For culverts 75 feet or longer, drill an additional boring for every 75 feet of length increment or fraction thereof.

Culvert borings shall be drilled to a depth that will provide 30 tons minimum bearing for a 12-inch diameter metal shell pile. Boring shall be extended at least 10 feet below soils having blow counts less than 10 blows per foot and/or Qu less than 1.0 tsf. Sampling shall be at 2.5 foot intervals. If bedrock lies above the proposed boring termination depth, core the bedrock for a minimum depth of 5.0 feet in each boring.

3.6.3.4 Sign Structures and Toll Monotubes

Drill one boring at each Sign Structure support location. Borings for sign structure foundations should be drilled to a depth of at least 5.0 feet beyond the bottom of the drilled shaft foundation as indicated on the Illinois Tollway standard sign structure drawings for the anticipated sign structure type at the intended location. Borings shall be extended at least 10 feet below compressible soils. Sampling shall be at 2.5 foot intervals. If bedrock lies above the proposed boring termination depth, core the bedrock for a minimum depth of 5.0 feet in each boring.

3.6.3.5 Building Structures

For maintenance and toll buildings, drill a minimum of two borings at opposite corners; however, boring spacing shall not be more than 100 feet. Each boring shall be performed to a depth of at least 20 feet below footing elevation. Boring shall be extended at least 10 feet below compressible soils. Sampling shall be at 2.5 foot intervals. If bedrock is encountered at or above the proposed footing elevation, core the bedrock for a minimum depth of 5.0 feet in each boring.

3.6.3.6 Communication and High Mast Light Towers

For self-supporting towers (i.e., distance between legs measures less than 25 feet), drill one boring at the center to a depth of 50 feet below the proposed grade. If bedrock is encountered above the termination depth, the boring shall be cored to a depth of 10 feet into bedrock. For anchored towers, drill one boring at the center point and one boring at each anchor location to a depth of 20 feet below foundation level. Boring shall be extended at least 10 feet below compressible soils. Sampling shall be at 2.5 foot intervals to a depth of 30 feet and at 5.0 feet thereafter.

3.6.4 Borrow Areas

Each borrow area proposed by the Designer/Illinois Tollway shall be investigated either with borings or test pits to a depth of 5.0 feet below proposed bottom of cut. Boring or test pit spacing shall be decided based on the initial study of the local geology and other available geotechnical data. It is suggested to perform one boring/test pit for every 20,000 square feet area. Sampling shall be at 2.5 foot intervals to the depth of borings or test pits. At least one bulk

sample for a compaction test shall be obtained per material type and per 30,000 cubic yards of borrow excavation. These samples shall be selected so that they best represent the available materials from the borrow area. Exploratory borings or test pits shall also be made to investigate the suitability of soils from cuts and excavations for use as embankment materials within the same project area.

### 3.6.5 Peat Bogs, Swamps, and Marshes

The lateral extent and depth of soil deposits such as peat or other highly organic or soft materials shall be delineated at 50 foot intervals along and perpendicular to the centerline. Soil shall be sampled continuously to a depth of at least 10 feet below the weak, compressible deposits. Where ground improvement design is necessary, the GE shall prepare a specific geotechnical investigation program and submit it for approval to the Designer/Illinois Tollway.

### 3.6.6 Retention Basins, Detention Basins, Bioswales and Wetlands

For retention basins, detention basins and wetland compensation areas, drill one boring per 15,000 square feet of surface area, with a minimum of 3 borings within each basin. Borings shall be drilled to a depth of at least 15 feet below the lower of the existing or proposed elevation.

For retention/detention basins and bioswales percolation, tests shall be completed to ascertain the potential rate of infiltration expected. Testing is recommended to be performed at the same interval as the soil borings for retention/detention basins. For bioswales, testing is recommended to be performed at the proposed ends and at intervals not to exceed 500 feet. In addition, testing shall be performed at all changes in soil type.

### 3.6.7 Other Facilities

Borings may be required for other facilities such as light poles, traffic signals, and deep drainage structures. The Designer or the Illinois Tollway shall identify and provide details for such facilities. The boring program shall be developed by the GE in collaboration with the Designer/Illinois Tollway at the appropriate design stage.

### 3.6.8 Landscape Areas

The GE may be required to perform shallow borings either by hand augering or other methods and obtain soil samples in landscape areas. The objective of the exploration program is to furnish accurate depth and quality information for the topsoil for bidding and contract execution. Mechanical and analytical laboratory analyses for topsoil may be required. The Designer or the Illinois Tollway shall provide a detailed program and requirements for this work.

Topsoil sampling shall be performed throughout the project limits at approximately 300 to 500 foot intervals, measured along the centerline of the roadway, to determine the suitability of the topsoil material for reuse and to provide existing depth information that may be used for estimating contract quantities. Borings shall be staggered between edge of shoulder and the construction limit of the project. Borings in a fill section shall be staggered between the near

shoulder and the ditch bottom of the existing embankment. The borings shall penetrate to a depth of at least three feet below the existing grade.

Boring location maps and soil profile drawing shall be included in the geotechnical report. As required, samples may be classified using the AASHTO and/or USDA soil classification systems.

The Illinois Tollway TOPSOIL AND COMPOST special provision provides the requirements for excavating, furnishing, and stockpiling topsoil. The Designer shall be familiar with the special provision and its application for the project and shall be responsible of earthwork computation.

### 3.6.9 Pavement Cores

The number, spacing, and locations of pavement cores shall be established based on the proposed pavement improvement and the specific project purpose of pavement investigation. As a minimum, consider taking one pavement core at every half mile per lane of traffic and shoulder. Observations on the pavements structure shall also be made within the boreholes drilled through the existing lanes and shoulders.

## 3.7 Boring Naming Convention

Borings shall be identified by the numbering system as per following method:

XXXX-YYY-ZZ
Where XXXX = Illinois Tollway Contract Number (Example, I-05-1234)
YYY = Functional or structural element of the project
ZZ = Numerical number

The following identification shall be used for the functional and structural elements.

BSB – Bridge Structure Borings
RWB – Retaining Wall Borings
NWB – Noise Abatement Wall Borings
TPB – Toll Plaza Borings
DPB – Detention Pond Borings
CRB – Cross Road Borings
ARB – Access Road Borings
CTB – Communication Tower Borings
OSB – Overhead Sign Borings
SSB – Slope Stability Borings
CB – Culvert Borings
SGB – Subgrade Borings for Mainline and Ramps
BAB – Borrow Area Borings
BFB – Buildings & Facilities Borings
SAB – Swamp Area Borings
WAB – Wetland Area Borings
LTB – Light Tower Borings

TSB – Traffic Signal Borings
DDB – Deep Drainage Structure Borings

Example: Boring Number 1234-SGB-12

## 3.8 Water Table Assessment

The GE shall identify the presence of water-bearing layers and determine the water table elevation. Record the elevations at which the water table was measured in each borehole during, at completion, and 24 hours after drilling (where feasible), as well as the depths at which water was lost or water was encountered under excess pressure.

When longer term groundwater monitoring is required, piezometers shall be installed according to ASTM D5092, "Standard Practice for Design and Installation of Groundwater Monitoring Wells."

## 3.9 Soil Assessment for Slab Jacking

For all slab jacking projects, soil borings are required to determine the relative strength of the subgrade soil/fill material. Borings shall extend through the pavement, base course and fill and extend a minimum of 5 feet in to the foundation soils, to a total minimum depth of 15 feet below the pavement surface. Samples shall be collected to determine the moisture content, grain size distribution and Atterberg limits of each layer which is encountered. Samples shall be collected continuously with SPT blow counts taken at 6 inch intervals to depths of 15 feet except for the following conditions:

- If refusal is encountered at a depth less than 15', the SPT test shall be abandoned and repeated at a location 3' from the original test. Refusal is defined as failure to advance the rod after an incremental blow count of 50.

- If the 15' depth is reached but the incremental blow count is still less than 10, continue the test until the incremental blow count is 10 or more or to a depth of 25', whichever occurs first.

Soil samples shall be collected accordance with ASTM D1586.

In areas of bridge approach slab jacking, a minimum of eight (8) borings will be necessary, with four borings along the left wheel path of the inside lane and the right wheel path of the outside lane spaced as follows:

- One near the end of the bridge approach pavement, in proximity to the sleeper slab or pile bent, but not necessarily through it;
- One 5 feet from the back of the bridge abutment;
- One 10 feet from the end of the bridge approach pavement (in the bridge approach slab);
- One 25 feet from the end of the bridge approach pavement (in the transition slab).

In areas roadway pavement slab jacking, a minimum of nine (9) borings will be necessary for each 3,600 square feet of pavement to be jacked in a single direction of traffic, with four (4) borings along the left wheel path of the inside lane and five (5) borings along the right wheel path of the outside lane as follows:

- Spaced at alternating 100 foot intervals.
- Spaced each way from the mid-point of the area to be jacked.
- Additional borings spaced at alternating 100 foot intervals should be added for each additional 300 lineal feet of pavement in a single direction needing slab jacking.

Additional testing/sampling locations should be added for identified “trouble spots”, e.g., structural distresses, pumping, persistent settlement, etc.

## SECTION 4.0 GUIDELINES FOR LABORATORY TESTING

### 4.1 Standards and Specifications

The GE's geotechnical laboratory shall be capable of performing soils and rock tests in accordance with standard IDOT, AASHTO, and ASTM testing procedures, and it shall be yearly inspected and approved by the IDOT Bureau of Materials. Laboratory tests shall be performed on representative samples to verify field classifications and to determine typical engineering properties of soil types encountered in the project area. The GE shall perform a sufficient number of laboratory tests to support report analyses and recommendations.

### 4.2 Laboratory Testing Program

The laboratory testing program shall be developed accounting for the specifics of each project and continuously reevaluated based on subsurface investigation results and design requirements and changes. The most common laboratory testing procedures applicable to Illinois Tollway geotechnical work are listed below:

- Particle Size Analysis of Soils (T-88);
- Determining the Liquid Limit of Soils (T-89);
- Determining the Plastic Limit and Plasticity Index of Soils (T-90);
- Laboratory Determination of Moisture Content of Soils (T-265);
- Specific Gravity of Soils (T-100);
- Laboratory Determination of Density (Unit Weight) of Soil Specimens (D-7263);
- Moisture-Density Relations for Soils Using a 2.5 kg Rammer and 305 mm Drop (T-99);
- Illinois Bearing Ratio (IDOT Geotechnical Manual);
- Determination of Organic Matter in Soils by Wet Combustion (T-194);
- Determination of Organic Matter by Loss-on-Ignition (D-2974);
- Unconfined Compressive Strength of Cohesive Soils (T-208);
- Direct Shear Test of Soils under Consolidated Drained Conditions (T-236);
- Unconsolidated-Undrained Compressive Strength Test Triaxial Compression (T-296);
- Consolidated-Undrained Compressive Strength Test Triaxial Compression (T-297);
- One-Dimensional Consolidation Properties of Soils (T-216);
- Determining pH of Soils for use in Corrosion Testing (D-4972);

The results of laboratory tests shall be presented in tabular and/or graphical form.

# SECTION 5.0 GEOTECHNICAL REPORTS

## 5.1 Geotechnical Report Requirements

Geotechnical report types, their applicability and relation with major Illinois Tollway design phases, as well as content requirements are presented in the following table:

| Tollway Design Phase | Geotechnical Report Type | Applicability | References (see Section 2.3) |
|---|---|---|---|
| Studies/Reports & Master Plan | Geotechnical Desk Study Report | Planning phase for major highways and/or major river or highway bridges | Section 7.2, IDOT Geotechnical Manual |
| Conceptual Design (30%) | Roadway Geotechnical Report (RGR) | Roadway and pavement design, including embankment and slope stability | Section 7.3, IDOT Geotechnical Manual |
| | Structure Geotechnical Report (SGR) | Structures that require Type, Size and Location (TS&L) plans (bridges, retaining structures, and culverts) | AGMU 05.2; AGMU 12.0 |
| Preliminary Engineering Phase (60%)<br><br>Pre-final Design Phase (95%)<br><br>Final Check Design Phase (100%) | Geotechnical Design Memorandum | As necessary for revisions to SGRs due to major TS&L changes (redesign); ground improvement design; refinement of foundation type or size and/or stability and settlement evaluations based on additional or advanced in-situ and laboratory testing | AGMU 12.0 |
| Any Design Phase | Geotechnical Letter Report | Small retaining structures and culverts that do not require TS&L plans, sign structures, noise walls, parking lots, small buildings, detention basins, wetland compensatory areas, borrow source evaluation, other facilities | Established practice |
| | Geotechnical Data Report | Pavement and bridge structure investigations, topsoil investigations, boring logs, in-situ tests and results, and laboratory test results for any geotechnical design performed by others | Established practice |

## 5.2 Geotechnical Report Submittal and Review Process

As appropriate for every design phase, the GE shall submit for Designer/Illinois Tollway review draft geotechnical reports meeting the requirements listed in Section 5.1. As necessary, Designer/Illinois Tollway shall provide to the GE in a timely manner the drawings and documents required for preparing complete draft reports, including but not limited to design pavement structure; hydraulic report; topographic survey; structure condition reports; preliminary roadway plan, profile, and cross section drawings; general plan and elevation drawings; anticipated design loads; and preliminary TS&L plans. Prior to submittal of the draft reports, the GE may be required to provide preliminary geotechnical results necessary to advance the development of design drawings and construction cost and quantity estimates, including but not limited to existing pavement structure thickness; topsoil thickness; preliminary boring logs; recommended foundation types; and preliminary pile/shaft type, size, and length estimates.

Final geotechnical reports shall address and incorporate comments made on the draft versions and final roadway plan and profile or TS&L drawings. A Professional Engineer licensed in the State of Illinois who has at least 10 years of experience in the field of geotechnical engineering and under whose supervision the geotechnical design work was performed shall stamp the final geotechnical report version.