

March 2022

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# Geotechnical Manual

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ILLINOIS STATE TOLL HIGHWAY AUTHORITY

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# INTRODUCTION

## Geotechnical Manual

The Geotechnical Manual provides a detailed listing of criteria, guidelines, policies and procedures to be followed by the Geotechnical Engineer for the Illinois Tollway. The manual's intent provides consistency for subsurface field investigations, laboratory testing and geotechnical reports with the benefit of uniform expectations of practices and procedures for the design and construction of Illinois Tollway facilities.

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The Geotechnical Manual dated March 2022 replaces the previous version dated March 2021.

### Revision Summary

- 5.1.1: Added article for supplemental report requirements for roadway and structural geotechnical reports.

# TABLE OF CONTENTS

<b>SECTION 1.0 INTRODUCTION</b>	<b>1</b>
1.1 Purpose and Use	1
1.2 Abbreviations and Acronyms	1
1.3 Definitions	2
<b>SECTION 2.0 GENERAL CONSIDERATIONS</b>	<b>3</b>
2.1 Project Organization and Procedures	3
2.2 Standards and References	3
<b>SECTION 3.0 GUIDELINES FOR FIELD INVESTIGATIONS</b>	<b>5</b>
3.1 Geotechnical Investigation Program	5
3.2 Desk Study	5
3.3 Site Visit	6
3.4 Permits and Utilities	6
3.5 Methods and Procedures	6
3.5.1 Soil Sampling	6
3.5.2 Bedrock Coring	7
3.5.3 Pavement and Bridge Coring	7
3.5.4 Other In-situ and Field Tests	8
3.5.5 Water Table Assessment	9
3.5.6 Backfilling Boreholes and Site Restoration	10
3.5.7 Field Boring Logs and Sample Preservation	10
3.6 Geotechnical Investigation Program Guidelines	10
3.6.1 Subgrade Borings	11
3.6.2 Stability Borings	11
3.6.3 Structure Borings	12
3.6.4 Borrow Areas	14
3.6.5 Peat Bogs, Swamps and Marshes	15
3.6.6 Retention Basins, Detention Basins, Bioswales and Wetlands	15
3.6.7 Other Facilities	15
3.6.8 Landscape Areas	15
3.6.9 Pavement Cores	16
3.6.10 Slab Jacking	16
3.7 Boring Naming Convention	16
<b>SECTION 4.0 GUIDELINES FOR LABORATORY TESTING</b>	<b>18</b>

- 4.1 Standards and Specifications \_\_\_\_\_ 18
- 4.2 Laboratory Testing Program \_\_\_\_\_ 18
- SECTION 5.0 GEOTECHNICAL REPORTS \_\_\_\_\_ 19**
- 5.1 Geotechnical Report Requirements \_\_\_\_\_ 19
  - 5.1.1 Supplemental Report Requirements to Roadway Geotechnical Reports and Structure Geotechnical Reports \_\_\_\_\_ 21
- 5.2 Geotechnical Report Submittal and Review Process \_\_\_\_\_ 21

## 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 current editions of the *Geotechnical Manual* and the All Geotechnical Manual Users (AGMU) Memoranda published by the Illinois Department of Transportation (IDOT); and guidelines provided by the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications are required to be followed in performing geotechnical investigations and engineering analyses.

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 of the investigations and analyses and providing 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 (DSE) 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
DSE	Design Section Engineer

FVS	Field Vane Shear
GE	Geotechnical Engineer
IDOT	Illinois Department of Transportation
Illinois Tollway	Illinois 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 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 carries 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 Illinois Tollway and Designer, if applicable. All field explorations, laboratory testing, soil profile drawings and engineering reports shall be submitted to the Illinois Tollway for review. All GE work shall be reviewed and approved by the Illinois Tollway prior to it being considered Final.

The Illinois Tollway and Designer, if applicable, 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, if applicable, the 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 Illinois Tollway and Designer, if applicable. 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. Field investigations shall begin only after the proposed geotechnical investigation program has been reviewed and approved by the Illinois Tollway for its conformance to the minimum requirements as set forth within this Manual.

### 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:

- AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications
- AASHTO Manual on Subsurface Investigations
- AASHTO Standard Specifications for Highway Bridges
- IDOT All AGMU Memoranda
- IDOT Bridge Manual



- IDOT *Culvert Manual*
- IDOT *Geotechnical Manual*
- IDOT Standard Specifications for Road and Bridge Construction
- IDOT *Subgrade Stability Manual*
- IDOT *Sign Structures Manual*
- Illinois Tollway *Design Section Engineer's Manual*
- Illinois Tollway *Structure Design Manual*
- Illinois Tollway Supplemental Specifications to IDOT Standard Specifications

This Manual does not address sampling or testing requirements of hazardous or special waste materials. The *Environmental Studies Manual* 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 Illinois Tollway and Designer, if applicable. Further work directions shall be discussed with the Illinois Tollway and Designer, if applicable.

## 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 Illinois Tollway for conformance to the minimum requirements as set forth within this Manual.

### 3.1 Geotechnical Investigation Program

The GE in coordination with the Illinois Tollway and Designer, if applicable, 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 to the Illinois Tollway 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 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 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, if applicable, and 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 Illinois Tollway and Designer, if applicable, 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, if applicable, 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 ton per square foot) and/or highly compressible soils in areas of proposed embankments or embankment widening, proposed retaining structures, or other areas 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 Army Corps of Engineers.

### **3.5.2 Bedrock Coring**

Continuous core samples shall be obtained by means of a diamond drill and double tube core barrel to yield continuous cores no less than 2<sup>1</sup>/<sub>8</sub>-inch (NX size) diameter in accordance with 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 4-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 Dynamic Cone Penetrometer (DCP) testing of subbase and/or subgrade are required. The method of coring shall be such to produce an intact core sample. The core holes in hot mix asphalt (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 in accordance with Table 1 of American Society for Testing and Materials (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 Illinois Tollway and Designer, if applicable, 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 in accordance with Table 1 of ASTM C928.

### 3.5.4 Other In-situ and 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.

**Rimac Test** – Rimac tests shall be performed on every SPT sample recovered unless the sample cannot hold shape, is cohesionless, or is of insufficient length for testing. Rimac equipment and testing procedures shall be in accordance with the *IDOT Geotechnical Manual*.

**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 in accordance with the *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 run 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 resistances 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 resistances; 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*.

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 may be 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 Illinois Tollway and Designer, if applicable.

### 3.5.5 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 completion of the borehole, as well as the depths at which water was lost or water was encountered under excess pressure. Due to various reasons, it may not be possible to take a 24-hour groundwater reading. In such cases, piezometers shall be installed and monitored to obtain the long-term groundwater elevation for a project area. The piezometers shall meet the requirements of ASTM D5092 *Standard Practice for Design and Installation of Groundwater Monitoring Wells*. When longer term groundwater monitoring is required, piezometers shall also be installed.

Variations to the recording frequencies as indicated above and proposed locations of piezometers must be approved by the Illinois Tollway. Should a borehole be abandoned without the minimum requirements for groundwater measurements as required herein without the permission of the Illinois Tollway, the GE shall make an additional boring at a location selected by the Illinois Tollway. No payment shall be made for either the abandoned hole or any samples or cores obtained from the abandoned hole.

### **3.5.6 Backfilling Boreholes and Site Restoration**

After samples, observations and information have been obtained, the holes and excavated areas shall be backfilled in accordance with 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.

### **3.5.7 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 ( $Q_u$ ) 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 and submitted for review and approval by the Illinois Tollway. The proposed boring program shall be in general accordance with the requirements as set forth herein, IDOT and AASHTO guidelines and based on preliminary plan and profile drawings provided by Designer or Illinois Tollway. Field investigations shall begin only after the proposed geotechnical investigation program has been reviewed and approved by the Illinois Tollway for conformance

to the minimum requirements as set forth within this Manual.

Consideration should be given to previously performed geotechnical explorations which may have been conducted along all or part of the proposed project limits. Under no condition, however, shall the design and construction of the proposed facilities rely entirely on previously performed geotechnical explorations. Unless otherwise approved by the Illinois Tollway, for verification purposes a minimum of one of every four borings required to meet the minimum standards for quantity/spacing as specified herein shall be performed by the GE. 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. Variations to the requirements set forth herein shall be identified within the submittal to the Illinois Tollway and must be approved prior to commencement of the investigation. As-drilled boring locations shall not vary by more than 15 feet from the proposed locations without approval from the Illinois Tollway.

### **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 split spoon sampler and shall be complemented with Shelby tube samples.

### **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 ( $Q_u$  less than 1 ton per square foot and/or moisture contents higher than 25%) are anticipated or encountered, this spacing shall 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 ( $Q_u$  equal or greater than 2 tons per square foot) are encountered. The soil shall be sampled with an 18-inch 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 split spoon sampler.

### 3.6.3 Structure Borings

#### 3.6.3.1 Bridges

As a minimum, for proposed bridge widths less than 76 feet, one boring at each pier, abutment and approach span bent with alternate borings on opposite sides of the centerline of the structure shall be performed. When the proposed bridge width is greater than 76 feet, two borings shall be made for each substructure unit. Dual structures shall be considered two separate structures. Therefore, for example, a proposed dual bridge structure less than 76 feet would require a minimum of two borings at each abutment line for a total of four abutment borings (i.e., both structures have one abutment boring on each of their respective abutments) and multiple pier borings.

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 Illinois Tollway and Designer, if applicable, to determine if additional subsurface data is required.

Borings shall be taken as close as possible to the proposed abutment and pier locations as practically possible. Boring locations shall be proposed by the GE and submitted for review and approval by the Illinois Tollway prior to them being conducted.

Unless rock is encountered first, bridge borings shall be drilled to a minimum depth that will provide a minimum Nominal Driven Bearing resistance of 500 kips for a 14-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-foot intervals thereafter. 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 5 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 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 heights greater than 20 feet, use a maximum boring spacing of 50 feet. In all borings, sampling shall be at 2.5-foot intervals to a depth of 30 feet below the bottom of wall level and at 5-foot intervals thereafter.

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  $Q_u$  less than 1 ton per square foot. 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, but in no case, less than twice the total height of wall below footing level. 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.

For temporary retaining walls, drill borings following the same depth requirements as listed above. For temporary walls less than or equal to 20 ft in height, the maximum boring spacing is 100 feet. For temporary walls greater than 20 feet in height, the maximum boring spacing is 75 feet.

If an existing retaining wall is located behind the proposed retaining wall, the total composite height shall be considered as the total retaining wall height when accounting for the boring spacing and depth.

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 feet in each boring.

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

### **3.6.3.3 Culverts**

Borings shall be obtained for culverts with cross sectional openings greater than 12 square feet. 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 below the flow line of the culvert of a minimum of a least two times the fill height above the culvert or until bedrock is encountered. Boring shall be extended at least 10 feet below soils having blow counts less than 10 blows per foot and/or  $Q_u$  less than 1 ton per square foot. 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 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 10 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 feet in each boring.

#### **3.6.3.5 Building Structures**

For building structures, drill a minimum of two borings at opposite corners of the structure for built-over areas of 5,000 square feet or less. For built-over areas greater than 5,000 square feet, drill at least one additional boring for each additional 5,000 square feet, or part thereof, of built over area. Each boring shall be performed to sufficient depths to fully determine the soil profile and at least a minimum of at least 10 feet below compressible soils, 20 feet below footing elevation for shallow foundations and 15 feet below the tip elevation for deep foundations. Sampling shall be at 2.5-foot intervals to a depth of 30 feet and at 5 feet below that depth. If bedrock is encountered core the bedrock for a minimum depth of 5 feet in each boring and a minimum of 10 feet below the deepest foundation element.

#### **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 feet thereafter.

### **3.6.4 Borrow Areas**

Each borrow area proposed by the Illinois Tollway or Designer shall be investigated either with borings or test pits to a depth of 5 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 Illinois Tollway and Designer, if applicable.

### **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 three 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 Illinois Tollway and Designer, if applicable, 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 Illinois Tollway and Designer, if applicable, 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.

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 in conjunction with the Illinois Tollway 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.

### 3.6.10 Slab Jacking

For bridge approach slab jacking, a minimum of eight borings shall be performed with half of the borings conducted along the left wheel path of the inside lane and the other half along the right wheel path of the outside lane. At a minimum, borings shall be spaced along each wheel path as follows:

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

For roadway pavement slab jacking shorter than 100 linear feet of pavement, drill two borings near the proposed ends. For pavement slab jacking 100 feet or longer, drill an additional boring for every 100 feet of length increment or fraction thereof. Borings shall alternate between the left wheel path of the inside lane and the right wheel path of the outside lane alternating at 100 foot intervals, or fraction thereof.

Additional borings should be performed for identified “trouble spots”, e.g., structural distresses, pumping, persistent settlement, etc.

Borings shall be a minimum depth of 15 feet below the pavement surface and the soil should be sampled continuously. If the 15-foot depth is reached but the incremental blow count is less than 10, continue sampling until the incremental blow count is 10 or more or to a depth of 25 feet, whichever occurs first. If refusal is encountered at a depth less than 15 feet, the boring shall be abandoned and offset to a location 3 feet from the original boring.

## 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  
LAB – Landscape Area Boring

Example: Boring Number 1234-SGB-12

## SECTION 4.0 GUIDELINES FOR LABORATORY TESTING

### 4.1 Standards and Specifications

The GE's geotechnical laboratory shall meet the requirements as set forth in the IDOT *Geotechnical Manual* including but not limited to being AASHTO re:source (formerly Materials Reference Laboratory) and IDOT Bureau of Materials inspected. 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.

### 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);
- Moisture-Density Relations of Soils using a 10-lb Rammer and 18-in dop (TI-80);
- Standard method of Test for Sieve Analysis of Fine and Coarse Aggregates (T-27).

The GE shall perform a sufficient number of laboratory tests to support report analyses and recommendations. At a minimum, lab testing for moisture content, slope stability applications, settlement and slope stability applications, rock cores and subgrade borings shall meet the minimum standards for type and quantity of testing as set forth in the *IDOT Geotechnical Manual*. In addition, a minimum of one particle size analysis (sieve and hydrometer), liquid limit, plastic limit and specific gravity shall be performed on each representative soil type encountered. The results of laboratory tests shall be presented in tabular and graphical form.

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## 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:



<b>Tollway Design Phase</b>	<b>Geotechnical Report Type</b>	<b>Applicability</b>	<b>References (see Section 2.2)</b>
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 settlement 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)	Section 7.4, IDOT Geotechnical Manual
Preliminary Engineering Phase (60%)  Pre-final Design Phase (95%)  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	Section 7.4, IDOT Geotechnical Manual
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

### **5.1.1 Supplemental Report Requirements to Roadway Geotechnical Reports and Structure Geotechnical Reports**

In addition to the report requirements set forth in the IDOT Geotechnical Manual and IDOT Bridge Manual, this section lists supplemental requirements by the Illinois Tollway. The reports shall be submitted within the applicable design phase, as presented in the table in Section 5.1.

#### **5.1.1.1 Ground Improvement Recommendations**

The geotechnical report shall include recommendations for undercutting (remove and replace) or other ground improvement methods, as needed, for all roadway embankments and structures. For undercut recommendations greater than 3 feet, various methods should be evaluated to reduce undercut thickness including the use of geotextiles. The evaluation shall include a cost-benefit analysis. The locations and depths of the ground improvement shall be included in the contract documents in addition to the temporary support systems required to complete the excavation.

#### **5.1.1.2 Downdrag**

When downdrag is anticipated, the geotechnical report shall include an evaluation of treatments and recommendations for the downdrag treatment method (as discussed in IDOT Bridge Manual and IDOT Geotechnical Manual). If precoring is recommended, recommendations shall include depths for temporary and/or permanent casing.

## **5.2 Geotechnical Report Submittal and Review Process**

As appropriate for every design phase, the GE shall submit for Illinois Tollway review draft geotechnical reports meeting the requirements listed in Article 5.1. As necessary, 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 Type Size and Location (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.