

March 2026

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# Geotechnical Manual

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ILLINOIS STATE TOLL HIGHWAY AUTHORITY

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# OVERVIEW

## 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.



The Geotechnical Manual dated March 2026 replaces the previous version dated March 2022.

**Major Revision Highlights:**

<b>Section 1.0: Introduction</b>	
<a href="#">Article 1.1</a>	Added paragraph to better describe the scope of the manual. Edited paragraphs to increase the Geotechnical Engineer’s participation in contract document preparation. Included technical memorandums in subsurface investigations and engineering analyses.
<a href="#">Article 1.2</a>	Added abbreviations to reflect more terminology.
<b>Section 2.0: General Considerations</b>	
<a href="#">Article 2.1</a>	Edits to paragraphs to include Geotechnical Engineer’s working directly for a contractor under performance specifications of completing construction engineering tasks.
<a href="#">Article 2.2</a>	Added references related to geotechnical reporting guidelines.
<b>Section 3.0: Field Explorations</b>	
<a href="#">Section 3.0</a>	Updated section name to reflect latest content and reworded restriction regarding site evaluation by the driller.
<a href="#">Article 3.1</a>	Reordered and renamed article, moving it from 3.3 to 3.1. Updated to include evaluation of access and traffic control during site visits.
<a href="#">Article 3.2</a>	Reordered and renamed article, moving it from 3.1 to 3.2. Edited to include access and permit restrictions, and drilling submittal requirements as related to the size of the project.
<a href="#">Article 3.3</a>	Reordered article, moving it from 3.2 to 3.3, and restructured it for clarity.
<a href="#">Article 3.4</a>	Edited to reflect the current utility locating requirements. Safety and traffic control measures were also added.
<a href="#">Article 3.5.4</a>	Expanded article to include more geophysical exploration methods and deep foundation testing. Additional edits to clarify digital piezocones.
<a href="#">Article 3.5.6</a>	Includes updated information on borehole backfilling with sand.
<a href="#">Article 3.6.3.1</a>	Updated article for clarity and for latest boring requirements. Minimum rock core length increased to 15 feet for bridges.
<a href="#">Article 3.6.3.4</a>	Changed article to include monopoles and sentences were added regarding maximum offsets for drilling at tolling facilities.
<a href="#">Article 3.6.5</a>	Retitled and redefined article to reflect borings for ground improvement areas.
<a href="#">Article 3.6.11</a>	Added new article to included explorations for pipe trenchless installations.

<b>Section 4.0: Guidelines for Laboratory Testing</b>	
<a href="#">Article 4.2</a>	Removed requirement on laboratory test result presentation.
<b>Section 5.0: Geotechnical Reports</b>	
<a href="#">Article 5.1</a>	Added new criteria to Table 1-0 called “Proposed Work Plan Submittal” in the “Geotechnical Report Requirements” for the conceptual design (30%) phase as well as additional language to clarify preliminary geotechnical reports compared to final reports.
<a href="#">Article 5.1.1.1</a>	Added information on newer methods of ground improvement.
<a href="#">Article 5.1.1.3</a>	Added new article that discusses reporting methods and preliminary evaluation for shallow foundations.
<a href="#">Article 5.1.1.4</a>	Added new article that discusses reporting methods for noise abatement walls.
<a href="#">Article 5.1.1.5</a>	Added new article that discusses reporting methods and design criteria for helix foundations.
<a href="#">Article 5.2</a>	Added new paragraph requiring review of plans by the geotechnical engineer.
<b>Section 6.0: Construction Considerations</b>	
<a href="#">Article 6.1</a>	Added new article that discusses instrumentation and monitoring.
<a href="#">Article 6.2</a>	Added new article that presents a construction considerations checklist.
<a href="#">Article 6.3</a>	Added new article that discusses the installation of sewers or other utility lines with trenchless methods added.

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## SECTION 1.0 INTRODUCTION

### 1.1 Purpose and Use

The Geotechnical Manual provided herein standardizes the Illinois Tollways approach for the Geotechnical Engineer (GE) providing engineering services that affect the design and construction of the Illinois Tollway's facilities. Geotechnical engineering services may include evaluation for the projects may include site visits, subsurface investigation, laboratory testing and analyses, instrumentation and monitoring, engineering evaluation and design, and reporting. The GE should be involved in the plan preparation stage to verify that the geotechnical recommendations are incorporated, and the boring information is included. Also outlined herein are the Illinois Tollway's geotechnical design criteria, implementation or mitigation strategies and typical designs. The work performed by the GE under these requirements shall consist of planning the exploration programs; performing surface, subsurface and laboratory testing programs; carrying out geotechnical engineering analyses and providing recommendations for adequate geotechnical design and construction of the Illinois Tollway's facilities. In addition to this Manual, the current editions of the IDOT Geotechnical Manual and the All-Geotechnical Manual Users (AGMU) Memoranda published by the Illinois Department of Transportation must be followed. Additionally, guidelines provided by the American Association of State Highway and Transportation Officials (AASHTO) for Load and Resistance Factor Design (LRFD) and Bridge Design Specifications are required to be followed while 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 exploration and foundation soil investigations through an adequate program of field sampling, laboratory analyses and testing.
- Performing engineering analyses and evaluations and submitting the results of the investigations and analyses with recommendations in geotechnical reports and technical memorandums.

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's 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 with 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
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
CPT	Cone Penetration Testing
CSL	Crosshole Sonic Logging
DCP	Dynamic Cone Penetrometer
DSE	Design Section Engineer
EOR	Engineer of Record
ERI	Electrical Resistivity Imaging
FVS	Field Vane Shear
GE	Geotechnical Engineer
GPR	Ground Penetrating Radar
HDD	Horizontal Directional Drilling
HEL	Helix or Helical Piers
IDOT	Illinois Department of Transportation
Illinois Tollway	Illinois State Toll Highway Authority
MASW	Multichannel Analysis of Surface Waves
PE	Professional Engineer
PDA	Pile Driving Analyzer
PMT	Pressuremeter Testing
RGR	Roadway Geotechnical Report

ROW	Right of Way
RQD	Rock Quality Designation
SCP	Static Cone Penetrometer
SGR	Structure Geotechnical Report
SHAFT	Shaft Area Profile Evaluator
SOE	Support of Excavation
SPT	Standard Penetration Testing
SQUID	Shaft Quantitative Inspection Device
TIP	Thermal Integrity Testing
TS&L	Type Size and Location
USDA	United States Department of Agriculture
WEAP	Wave Equation Analysis of Piles

### 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 the Illinois Tollway’s work.

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 performance-based design 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 the Designer, as 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 being considered final.

The Illinois Tollway and the Designer, if applicable, shall issue instructions pertaining to the work and provide direct contact with the GE throughout the project. The GE shall assign a project manager who will be responsible for supervising the 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 the Illinois Tollway's Project Manager if work is done under a direct Illinois Tollway contract. Work performed by the GE under a Contractor for a performance-based design or in fulfillment of a construction engineering task will be coordinated through the Contractor's Project Manager and may be subject to specific review by the Designer and the Illinois Tollway as applicable.

The GE shall coordinate work with the Illinois Tollway and the 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 or the 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. Additionally, the GE must proactively and carefully consider the safety aspects related to the implementation of the exploration program in the field and transmit them to the different parties involved.

### 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*
- *FHWA Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications*
- *FHWA Soils and Foundations Reference Manual*
- *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 the Designer, if applicable. Further work directions shall be discussed with the Illinois Tollway and Designer, as applicable.

## SECTION 3.0 FIELD EXPLORATIONS

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. Driller's logs shall not be used to evaluate 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 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 existing construction limitations and impacts on nearby structures, evidence of distress or deformation in the existing pavements and foundations and signs of approach slab settlement shall be examined during the site visit. The test borings may be located within the Illinois Tollway's median or shoulders, on slopes adjacent to roadways, within the Illinois Tollway's ramp enclosures, or in other areas where vehicular traffic is limited. During initial field visits, the GE shall evaluate difficulties in successfully reaching and/or performing work at the site, evaluate access and traffic control requirements, and include the results of the evaluation in the proposed work plan submitted to the Illinois Tollway and Designer.

### 3.2 Geotechnical Exploration Program

The GE, in coordination with the Illinois Tollway and the Designer, if applicable, shall prepare a proposed work plan submittal. This includes a general description of proposed engineering works and estimated number and location of borings or other means of exploration, termination depths, effort required to access boring locations, traffic control requirements, access and permit restrictions, anticipated in-situ and laboratory tests, labor hours required to complete the proposed work and schedule of completion. Projects with four or less isolated borings proposed for sign foundations or monopole design do not require a proposed work plan submittal.

The geotechnical exploration program, including boring locations on drawings showing the existing and proposed site conditions, if available; proposed traffic control requirements for access; the types and estimated depths of samples and laboratory testing to be performed, shall be submitted to the Illinois Tollway for approval following the completion of the desk study and site visit prior to the start of the field exploration. The geotechnical exploration shall be adjusted to accommodate design changes and/or unexpected subsurface conditions during execution in the field. Major changes to the exploration program that impact budget or schedule of completion shall be approved by the Illinois Tollway. Should a borehole be abandoned or not be 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 coordinated by the GE with the Illinois Tollway.

Project completion may require input from environmental consultants in coordination with the GE

or as determined by the Illinois Tollway.

### 3.3 Desk Study

A desk study shall be performed before any investigation program is started. The desk study shall include review of the following:

- Geological settings.
- Existing geotechnical boring and water well records.
- Existing bridge drawings.
- Foundation installation records.

The GE shall evaluate for usefulness and consider the existing subsurface information when planning and performing the field investigation, assigning laboratory testing, performing engineering analyses and providing foundation recommendations. The desk study will help identify potential conditions that could lead to project delays caused by issues such as the presence of miscellaneous fill and peat deposits.

The use of previous data shall be at the 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.

### 3.4 Permits and Utilities

The GE shall be responsible for identifying utilities in the area by following the A-36 Illinois Tollway Locating Procedure. The digger shall contact J.U.L.I.E. to obtain utility clearance. Field crews shall follow the markup requirements and maintain a safe working distance from both overhead and buried utilities. The Illinois Tollway's underground facilities must be located and marked before any underground work is started on Tollway property.

As part of the proposed work plan to identify utilities within project limits, the GE shall develop a project-specific safety plan, including a traffic control plan, if applicable. Contractors should mirror the Designer's Health and Safety Plan for field exploration. In coordination with the drilling or exploration, all subcontractors are to ensure the safety of both the travelling public and the personnel performing the explorations in the field.

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

The GE shall develop a maintenance of traffic (MOT) plan in accordance with the Illinois Tollway Supplemental Specifications and Section E of the Illinois Tollway Standard Drawings that is site specific to the proposed exploration program and in coordination with the drilling or exploration subcontractor. The MOT plan shall be submitted to the Illinois Tollway for approval prior to any field work.

## 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 labeled 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 6 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 types 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 glass jars of similar types and sizes.

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 U.S. 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 U.S. 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) in 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 partitioned so the cores from each boring will be kept separate and properly placed in the order in which they were removed from the core barrel to show where portions, if any, were lost. Adjacent runs shall be separated by 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 Dynamic Cone Penetrometer (DCP) testing of subbase and/or subgrade are required. The method of coring used shall produce an intact core sample. The core holes in hot mix asphalt (HMA) pavement shall be backfilled and patched with a 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 the 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 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 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 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 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 Tests** for 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 Tests** are 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 plotted shows 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 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 very dense soils.

Generally, soil samples are not obtained with soundings, so cone penetrometer exploration shall be complemented with SPT borings or other borings with soil samples taken.

Digital piezocones may be used to measure pore water pressure and excess pore water pressure dissipation which is useful for soils that are very sensitive to sampling techniques.

Digital piezocones may be fitted with strain gauges, load cells, inclinometers or geophones above the friction sleeve. The additional instrumentation can be used to measure shear wave velocities and obtain multiple soil characterization parameters with a single test.

- **Geophysical Exploration Methods** are non-destructive testing procedures that measure differences in physical earth properties, such as seismic, gravitational or electromagnetic responses. These measurements detect differences or anomalies in these parameters, which allow the characterization of the soil stratigraphy, bedrock profile or existing substructures. The results of geophysical explorations provide indirect information on the general subsurface profile, depth to bedrock, bedrock profile and engineering properties, presence of karst features, extent of peat deposits, presence of voids and buried utilities, corrosion potential or rebar. The measurement of shear or longitudinal waves in the ground allows the characterization determination of the overburden response to seismic loading and measurement of vibrations generated by construction activity. These seismic geophysical methods include Seismic Refraction, Seismic Reflection and Surface Wave (MASW) methods and employ a source of seismic disturbance, such as a hammer striking the ground, a rifle shot or a controlled explosion and measure the created waves. The advantage of the seismic methods is that they can be used in different types of terrain, are relatively quick to run and provide a good approximation of the subsurface profile and depth to rock based on the interpretation of the shear wave velocity. However, data processing is time consuming, and interpretation requires geologic knowledge and expertise.

Electrical resistivity imaging (ERI) is a useful geophysical exploration method that utilizes the subsurface materials resistance to electrical current flow to determine soil types, subsurface cavities and delineate changes in stratigraphy. By measuring the difference in electric potential between electrodes in the ground, ERI can be used to generate 2D or 3D imaging. It can be used to delineate the depth and extent of organic deposits or underground cavities, and to obtain a top of bedrock profile.

Ground Penetrating Radar (GPR) is a geophysical exploration method that uses high frequency radar pulses to generate subsurface images. It is useful to image near surface conditions, including buried pipes, tanks, pavement structure, urban fill and top of water table. It can also be used to identify zones of rebar corrosion or voids in and below existing substructures.

The GE shall consider supplementing the proposed exploration program with geophysical exploration for projects that include the evaluation of existing concrete structures, bridge decks, foundations, pavements and shallow limestone or dolomite bedrock.

- **Deep Foundation Inspection** includes the development of other physical testing methods that have improved the reliability of quality control for deep foundations, as compared to

geophysical testing methods.

Physical testing reflects the measurement of transient physical properties of concrete or steel structural elements, such as sonic wave or shock wave velocity. Based on these measurements, the use of wave equation analysis (WEAP modeling in the office and Pile Driving Analyzer or PDA in the field) or sonic logging (Cross-hole Sonic Logging, CSL) have been developed.

The GE shall consider and recommend the use of these deep foundation inspection methods on all projects that include driven pile or drilled shaft foundations and explicitly note preliminary results and installation criteria in their geotechnical reports.

The use of dynamic wave evaluation methods shall be recommended by the GE for all projects with driven piles. The structure geotechnical report shall recommend the different applications of these methods for the project, including the preliminary results of the WEAP model for the site stratigraphy and an assumed pile driving hammer commonly used in the area, the use of the PDA to verify pile capacity and setup if the piles are not driven to rock and CAPWAP models to verify capacity as applicable.

All drilled shaft foundations should be inspected during installation for various Tollway structure applications, including bridge substructures, retaining walls, noise abatement walls, overhead signs and light or camera poles.

Drilled shafts less than 15 feet in depth can be inspected by visual inspection of the excavation and installation of reinforcing steel configuration (cage) from the surface and using typical construction and material testing methods during concrete placement. Drilled shafts with depths greater than 15 feet or larger than 36 inches in diameter should be inspected using cross-hole sonic logging testing (CSL). Drilled shafts with depths greater than 15 feet and diameters less than 36-inches should be inspected with Thermal Integrity Testing (TIP). For larger-diameter drilled shafts, TIP should be applied only as a complement to CSL, at the discretion of the GE.

The GE should explicitly recommend the number of tubes and tube material for each of the proposed drilled shaft diameters to obtain sufficient data and avoid problems during testing. The tubes should not be grouted shut until approval of CSL and/or TIP test results by the GE.

For drilled shafts placed in a continuous row for noise abatement walls or retaining walls and at depths greater than 15 feet, the minimum frequency of CSL or TIP testing should be one (1) shaft for every six (6) drilled shafts in sequential order. The frequency can be increased depending upon anticipated subsurface bearing conditions, or reduced after verification of shaft installation techniques and production, at the discretion of the GE.

Other drilled shaft testing methods such as area profile measurements (SHAFT) and quantitative bottom inspection (SQUID) can also be considered and recommended as applicable for all drilled shaft applications.

### 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 refer to Articles 4.4.2.1 and 4.4.2.2 of IDOT Manual for borehole backfill but revise the backfill requirements for pavements, slabs or shoulders to include an upper 5-foot-thick layer of sand instead of borehole cuttings, immediately underneath the borehole concrete cap, to reduce the likelihood of surface settlement.

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.

### 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 setup, 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 Exploration 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 the Designer or the 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, crossroad, interchange ramp and parking area pavements.

In general, soil borings for the mainline of the Illinois Tollway shall be made at 150-foot intervals alternating in direction of traffic. Borings for crossroads, interchange ramps and access roads 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**

For proposed bridge widths of less than 76 feet, one boring shall be performed at each pier. Each pier, abutment and approach span bent borings shall be performed with alternate borings on opposite sides of the centerline of the structure.

When the proposed bridge width is greater than 76 feet, two borings shall be made for each substructure unit. A dual bridge shall be considered two independent bridges. Therefore, a proposed dual bridge, with less than 76 feet, would require a minimum of two borings at each

abutment line and a minimum of two boring at each pier line.

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 or proposed foundation shall govern: drill two borings where spread footings are present and one deep boring down to the bearing layer 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 15 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 the 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 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. If the temporary wall is less than or equal to 20 ft in height, the maximum boring spacing is 100 feet. If the temporary walls are 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 combined 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 in length, drill one boring near the proposed ends. For culverts with length equal to 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 at 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 one 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, Monopoles and Toll Monotubes**

Drill one boring at each 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.

Borings shall be drilled within 10 feet of the centerline of the proposed tolling structure unless

approved by the Illinois Tollway.

### **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, the distance between legs measures less than 25 feet, drill one boring at the center of the tower 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 desktop 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 Areas for Ground Improvement**

The lateral extent and depth of soil deposits such as peat bogs, swamps and marshes 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.

If ground improvement is identified as necessary based on a review of the desktop study, the GE shall identify the concern and prepare a specific geotechnical exploration program to delineate and characterize the area to allow ground improvement design and submit it for approval to the Illinois Tollway and Designer, if applicable. The GE shall complete all ground improvement designs by including a minimum of two different alternatives at preliminary design stage and present the associated characteristics or impacts of each alternative. Items such as slope stability, potential for long term settlement, and instrumentation for surcharge with excess fill, estimated time of surcharge, support of excavation for undercuts, or depths of improvement for intermediate foundations shall be presented.

### **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 and/or 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 consultation 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 of 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 3 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 for earthwork computation.

### 3.6.9 Pavement Cores

The spacing, locations and number 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. At 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.

### 3.6.11 Trenchless Installations

For trenchless installation projects, at least three test borings are required, with borings carried out at the launching and receiving pits as well as along the planned alignment. At a minimum, the borings along the alignment shall be spaced as follows:

- One boring near the midpoint between the access pits for lengths of 300 feet or less.
- One boring every 200 feet to the extent practical that facilitates the understanding of the ground conditions prior to performance of the work.

Additional borings should be performed for potential trouble spots. These are areas where desk and field studies have determined the potential for bedrock or other obstacles that might interfere with construction work.

Borings shall be advanced to a minimum depth of 10 feet below the estimated access pit bottom elevation or the pipe invert elevation at boring locations away from access pits. The borings should be advanced with continuous sampling.

### 3.7 Boring Naming Convention

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

**XXXX-YYY-ZZ**

- XXXX = The Illinois Tollway’s Contract Number
- YYY = Functional or structural element of the project
- ZZ = Numerical number

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

**Bridge Structure Borings**

- BSB – Bridge Structure Boring
- 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
- SAB – Swamp Area Borings
- CB – Culvert Borings
- SGB – Subgrade Borings for Mainline and Ramps
- BAB – Borrow Area Borings
- BFB – Buildings & Facilities 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 AASHTO and IDOT Bureau of Materials and Physical Research. 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 the Illinois Tollway's 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-inch drop (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.

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## SECTION 5.0 GEOTECHNICAL REPORTS

### 5.1 Geotechnical Report Requirements

Geotechnical report types, their applicability and relation with the Illinois Tollway's major design phases as well as content requirements are presented in Table 1-0.

**Table 1-0 Geotechnical Report Requirements**

<b>Tollway Design Phase</b>	<b>Geotechnical Report Type</b>	<b>Applicability</b>	<b>References (see Section 2.2)</b>
Studies/Reports and Master Plan	Geotechnical Desk Study Report	Planning phase for major highways and/or major river or highway bridges	Section 7.2, IDOT Geotechnical Manual
Studies/Reports and Master Plan or Conceptual Design (30%)	Proposed Work Plan Submittal	Plan exploration program, identify access, safety and traffic control issues	
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

	<p>Geotechnical Data Report</p>	<p>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</p>	<p>Established practice</p>
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All final geotechnical memorandums, generated in the final design phase, shall include an exclusion list that indicates any departures from the requirements set forth in this manual.

The GE shall prepare and submit a preliminary geotechnical report, as compared to a preliminary feasibility geotechnical report, to support the initial stages of design development. The purpose of the preliminary report is associated with selection of specific foundation systems that could vary based on supplemental evaluation such as scour depths, acceptance of preliminary settlement estimates, or further definition of ground improvement methods. A final geotechnical report with final design parameters such as a more precise loading estimate or final substructure dimensions and elevations will be necessary. Exceptions to this requirement include geotechnical evaluation for storm sewers, culverts, parking lots, signal foundations, noise abatement walls or other projects anticipated to meet the criteria for an abbreviated structure geotechnical report.

**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.

**5.1.1.1 Ground Improvement Recommendations**

If ground improvements are needed, the geotechnical report shall include recommendations for ground improvement such as undercutting (remove and replace) or other methods for all roadway embankments and structures. Ground improvement methods shall be evaluated using project-specific considerations. Table 2 presents different ground improvement methods with corresponding applicability criteria.

For undercut recommendations deeper than 3 feet below grade, alternative methods to reduce undercut thickness such as the use of geotextiles and geogrids to build a crushed stone-geogrid load distribution platform should be evaluated. Other ground improvement methods such as rammed aggregate piers, rigid inclusions, stone columns or wick drains in combination with site preloading could be considered depending on project applicability. Undercuts deeper than 5 feet should include an evaluation of the required lateral support system.

The evaluation of ground improvement shall include a cost-benefit analysis that takes into consideration schedule impacts, testing, instrumentation and geotechnical monitoring. For stone columns, rammed aggregate piers or rigid inclusions, an evaluation of pre-coring or pre-augering

should be included. Site preloading should include a detailed slope stability analysis, settlement estimates and associated monitoring requirements. The installation locations and proposed depths of the ground improvement shall be included in the contract documents in addition to the need and possible alternatives for temporary support systems as required.

**Table 2-0 Ground Improvement Comparison**

Ground Improvement Method	Maximum Bearing Pressure or Capacity	Ideal Applications	Treatment Depth	Other Considerations
<b>In-situ Reinforcement</b>				
Stone Columns	3–6 ksf	Lightly to medium loaded structures, liquefaction mitigation	30–100 ft.	Top-fed columns have limited treatment depth, but bottom-fed columns can reach deeper. Large cranes required for bottom-fed system require wide, open spaces, working platform to support heavy equipment, large onsite stone stockpile.
Rammed Aggregate Piers	4–8 ksf	Lightly to medium loaded structures, liquefaction mitigation	30 ft.	Limited lateral compaction in clay soils, little spoil volume generated.
Rigid Inclusions	5–10 ksf	Medium to heavily loaded structures	100 ft.	Weak strata and organic soils, little spoil volume generated.
Soil Nailing	5–20 kips	Temporary support of excavation in combination with shotcrete, flexible system	NA	Self-drilling bars facilitate installation for temporary applications; use of centralizers is necessary for corrosion protection in permanent applications which are less common.
Micro piles	100–400 kips	High-capacity tension elements, efficient with shallow rock, low headroom	200 ft.	High-cost and high-capacity drilled deep foundation elements with installation flexibility. Length adjustment/verification based on testing needed before going into production.
Ground Anchors	40–200 kips	High-capacity lateral support or tension elements	NA	Corrosion protection is needed for permanent elements. Installation becomes more difficult in soils with high cave-in potential that may require temporary casing for support.
<b>Densification</b>				
Preloading	2–4 ksf	Open areas with readily available fill, no schedule constraints	20–50 ft.	Settlement monitoring required.

Surface Densification	3–6 ksf	Loose granular soils above the water table	10–35 ft.	Disruptive and noisy process can cause negative reactions from users and neighbors. Vibration monitoring and preconstruction survey required for nearby structures. Not recommended for fine-grained, low permeability soils or high water table.
Wick Drains (In combination with preloading)	2–4 ksf	Extensive compressible clays below the water table, new roadway construction	20–50 ft.	Detailed slope stability modeling and settlement monitoring are required. The potential impact of the waiting period on the construction schedule must be accounted for.
<b>Constructed Earth Reinforcement</b>				
Undercut (excavation and replacement)	2–4 ksf	Shallow unsuitable soils, lightly loaded structures	2–5 ft.	Support of excavation for depths greater than 5 feet must be provided. High groundwater can impact applicability.
Chemical Treatment (lime or Portland cement subbase)	2–4 ksf	Increase subgrade support for pavement structures, increase workability of wet soils	< 2 ft.	Fissures of the treated subgrade can occur over extended drought periods. This method should be reviewed if proposed in residential areas.
Lightweight Fill	2–3 ksf	Embankments or retaining walls of medium height	NA	Lightweight fill has good highway applications in areas with soft soils and/or large settlement potential. Local availability of the material, encapsulation for durability and thermal isolation, limiting bearing capacity to 5% strain must be considered.
Geogrid Load Distribution Platform	3–6 ksf	Load distribution for lightly to medium loaded shallow footings, can be used to span between vertical elements such as stone columns	NA	System is easy to build at remote locations. Several layers of reinforcement should be considered for all applications other than subgrade reinforcement.
Reinforced Slopes and Embankments (GRS systems)	NA	Increase global stability over soft ground, increase subgrade support	NA	Detailed numerical modeling of the slope is required to verify long-term stability. Easy-to-construct system with increased acceptance that's proven to improve subgrade capacity.

**NOTES:**

1. List of soil improvement methods was based on ASCE Special Publication No. 12, Soil Improvement, a Ten Year Update, Edited by J.P. Welsh, April 28, 1987, and FHWA-NHI-16-027 Ground Modification Methods, Vols 1 and 2, April 2017

2. Maximum bearing pressure or capacity and treatment depth were based on ground improvement or construction projects published online and reflect a generalized guideline.
3. NA implies Not Applicable and was assigned to methods that cannot be directly associated with an increase in bearing capacity or treatment depth.

#### **5.1.1.2 Downdrag**

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

#### **5.1.1.3 Shallow Foundations**

The GE shall perform a preliminary evaluation of shallow foundations for the Illinois Tollway's facilities, such as bridges, retaining walls and toll plazas, to determine if these foundations are applicable.

Shallow footings can be used for bridges and ground-mounted noise abatement walls for sign structures, monotubes and monopoles at locations with shallow bedrock. Final design of shallow foundations shall be completed after the preliminary evaluation in accordance with *IDOT Geotechnical Manual* requirements, including assessment of settlement and global stability and bearing pressure limits for shallow footings near or on embankment slopes.

Due to the small footprint and light loads associated with toll plaza service buildings, locations with soils that have low shear strengths or significant settlement potential should be evaluated for ground improvement instead of deep foundations. The GE shall verify that the existing infrastructure will not conflict with any proposed ground improvement.

#### **5.1.1.4 Noise Abatement Walls**

The geotechnical valuation of noise abatement walls shall consider project constraints such as utilities, precast walls panel spans, wall support with drilled shafts, and the potential reduction of lateral soil restraint due to wall alignments on existing slopes on in soft soils. The GE shall provide an estimate of the lateral deflection at the top of the drilled shafts and identify locations along the wall alignment with the potential for increased drilled shaft lateral deflection.

Precast panel walls facilitate construction but also have the potential to ignore subsurface conditions in favor of standard drilled shaft layouts.

Locations with soft soils, more than 6 feet of retained soil or steeper slopes could be associated with shorter wall spans, larger drilled shaft diameters or require additional lateral support. The GE shall verify that the observed subsurface conditions and foundation recommendations for noise walls are reflected in the plans.

#### **5.1.1.5 Helix Foundation**

When helix foundations (also referred to as helical foundations) are anticipated, the GE shall identify soft soils with shear strengths below 1 ksf or a friction angle less than 26 degrees as

assumed in the Illinois Tollway Standard for light pole foundations. Soft soils between 2 and 5 feet deep can impact helix foundation embedment depths and may require reassessment of the helix foundation.

If these structures are isolated and without associated borings, the GE should identify the areas of soft soils by extrapolation between borings drilled within the general area and perform additional borings as needed.

A geotechnical report with helix foundation recommendations shall include installation criteria and a minimum depth penetration.

## 5.2 Geotechnical Report Submittal and Review Process

As appropriate for every design phase, the GE shall submit to the Illinois Tollway a draft copy of the geotechnical reports meeting the requirements listed in Article 5.1. As necessary, the 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.

The GE shall review the final plans and specifications to ensure the geotechnical recommendations are included.

## SECTION 6.0 CONSTRUCTION CONSIDERATIONS

In the development of construction specifications and requirements in the contract documents, the following should be considered.

### 6.1 Instrumentation and Monitoring

The GE shall evaluate the need for geotechnical monitoring, types of instrumentation and construction surveys, and include project-specific recommendations for these items. It is possible that nearby existing structures or railroad facilities could be impacted by the proposed construction. The GE shall establish the requirements to perform pre- and post-construction condition surveys, vibration and deformation monitoring and track monitoring during construction operations within a defined monitoring zone, and provide recommendations for the work. The monitoring zone shall include an area within a 200-foot radius of rock excavation, piling operations, drilled shaft construction, bridge demolition and bridge erection. In addition, the monitoring zone shall include all locations where the Contractor conducts any other type of construction operation within the vicinity of the railroad and shall be confirmed for site-specific railroad requirements. The instrument installation and monitoring would follow detailed design presented in a monitoring plan to be completed as a construction engineering task by others.

Specifications should include a monitoring plan, prepared by a GE working for the Contractor, to be submitted to the Illinois Tollway 30 days before the start of construction. The monitoring plan should identify all buildings/structures, railroad tracks, or the Illinois Tollway's facilities that are within the monitoring zone, outline the required instrumentation with instrument types and proposed locations, and alert threshold values.

A baseline deformation and vibration survey should be completed to obtain baseline data prior to the start of construction. The purpose of the construction condition surveys, and vibration and deformation monitoring are first to provide a baseline of existing conditions and then assist in the control of the Contractor's means and methods of construction within the monitoring zone by limiting construction vibrations and deformations to within established threshold values and to protect the Illinois Tollway from damage claims associated with construction of the Illinois Tollway's projects.

### 6.2 Construction Considerations Checklist

The GE shall discuss and provide construction-related observations in the appropriate document for the following items:

- **Temporary Soil Retention Systems (TSRS):** Define need for TSRS based on the proposed construction, present design requirements for inclusion in performance specifications, identify feasible systems of lateral support and associated benefits.
- **Overexcavation:** Present the proposed limits of overexcavation, propose field criteria to identify soils to be removed, discuss other soil improvement methods that were evaluated, indicate if temporary support of excavation will be required.

- **Preloading:** Indicate cross sections if surcharge is being recommended, describe required instrumentation; present estimated time for surcharge; provide guidelines to monitor pore pressures; identify wick drains if needed; provide estimated time to maintain surcharge, surcharge placement geometry and associated factor of safety.
- **Ground Improvement:** Recommend type of ground improvement, general characteristics, design requirements and construction issues associated with the recommended system.
- **Excavation:** Identify excavation at the toe of slopes and potential impact on safety and stability, provide open excavation factors of safety, indicate potential groundwater fluctuations, discuss needs for shoring.
- **Pile or Sheet Pile Driving:** Discuss the impact of pile driving on nearby structures; indicate potential impact of vibrations on nearby structures; roadways or railroad tracks; outline requirements for Pile Driving Analyzer use during installation; warn of the presence of boulders, dense or hard soils difficult to penetrate, or other obstructions; identify the need for predrilling or spudding.
- **Drilled Shafts:** Recommend monitoring systems for quality control during construction and outline proposed methods; present requirement for load cell test if needed; recommend testing frequency; discuss borehole support, boulders or obstructions, artesian conditions, casing requirements, potential vibrations from casing withdrawal and groundwater seepage.
- **Vibration and Deformation Monitoring:** Identify the requirements for vibration monitoring for the project and provide recommendations for vibration and/or deformation monitoring as required.

### 6.3 Trenchless Installations

This section presents geotechnical guidelines for trenchless installation projects. The Designer tasked with providing design recommendations or subsurface information for trenchless installations should use these guidelines as applicable to each project.

Trenchless installation of utilities beneath highways is an efficient and minimally invasive method for utility installations, pipes, cables and other infrastructure. Trenchless construction techniques involve creating underground pathways without the need for extensive surface excavation, thereby reducing traffic disruptions and preserving the integrity of the Illinois Tollway. One key consideration for trenchless installations is the strategic placement of boreholes. Refer to Article 3.6.11 for specific guidelines to plan a field exploration program for trenchless installations.

Common trenchless construction techniques include (suggested design standard):

- Horizontal Auger Boring – ASCE MOP 106
- Microtunneling and Pipe Jacking – ASCE 36-15
- Horizontal Directional Drilling (HDD) – ASTM F 1962

The GE shall identify the need for an instrumentation and monitoring program or preconstruction survey based on specific project conditions recommended to include in the contract documents.

When selecting trenchless methods for utility installation beneath highways, it is essential to select trenchless techniques that are compatible with the ground conditions expected and that minimize disturbance to the Illinois Tollway's assets.

Methods such as horizontal auger boring, pipe jacking, microtunneling and horizontal directional drilling (HDD) are some of the more common trenchless methods that may be effective in this regard, as they allow for control over the installation path and reduce the need for surface disruption. The ASCE and ASTM standards for these methods include ASCE MOP 106 for Horizontal Auger Boring, ASCE 36-15 for Microtunneling, and ASTM F1962 for HDD.