Illinois Department of Transportation

Memorandum

To:	ALL GEOTECHNICAL MANUAL USERS	12.0
From:	D. Carl Puzey	
Subject:	New Structure Geotechnical Report Categories and Scope	
Date:	June 15, 2012	

This policy memorandum has been issued to document the revised scope and provide guidance for preparing Structure Geotechnical Reports (SGRs) for all state and certain local projects. This memorandum supersedes AGMU 05.2 and sets new criteria, which were developed through a process review by geotechnical and structural consultants, as well as District and Bureau of Bridges and Structures office staff involved with scoping, negotiations, writing, approving, or using SGRs. The policies below should be implemented on all contracts negotiated after the effective date of the memorandum.

Multiple categories of SGRs are established to better match the expected complexity of various projects. For projects with no expected geotechnical challenges, *No SGR* will be required. For projects where limited geotechnical analysis is anticipated to be adequate, an *Abbreviated SGR* provides the necessary geotechnical recommendations. In all other cases, a *Typical SGR* will be required. A *Geotechnical Design Memorandum* will be required when geotechnical recommendations are best developed during the design phase or when changes in scope occur. These new SGR categories are intended to expedite TSL/SGR approval by reducing SGR requirements on certain projects, while deferring other requirements to the final design phase.

After completion of the Bridge Condition Report, existing information should be evaluated to determine what SGR category may be necessary. Such information includes the expected structure configuration, pile driving data, existing plans, and previous and/or new boring data. The following table is provided as general guidance in determining what SGR category is appropriate.

No SGR (borings only) Criteria	Abbreviated SGR Criteria	Typical SGR Criteria	Geotechnical Design Memorandum Criteria
Bridges with all of the following: • Single Span • Spill Thru (stub and integral) abutments • H-piles (no metal shells, spread footings, or drilled shafts) • Pile length to rock > 10' & < 40' • Less than 2 feet of fill added to embankment grade or slopes • Seismic Zone 1 • No permanent cut slopes > 15 feet **Walls with all of the following:** • Best wall type (MSE, T-type, Soldier, etc.) seems apparent • Exposed Height < 7 feet • Wall Foundation soils with min. Qu > 1.0 tsf. **Box Culverts with all of the following:** • Horizontal wings • Box foundation soils with Qu > 0.6 tsf • No more than 1 foot working platform under box • Fill height above box < 3 feet **All Structure Types:** • No challenging staging, construction, or subsurface issues and field visit indicates no visible geotechnical problems (i.e. existing slope failures, mine subsidence, tilting abutments or retaining walls, etc.)	**Bridges with:** • Best foundation Type (pile, spread, or shaft) seems apparent **Walls with:** • Best type (MSE, T-type, Soldier, etc.) seems apparent **Box Culverts with:** • No more than 2 feet of removal under box **3 sided Structures with:** • Best foundation type (pile, spread, or shaft) seems apparent **All Structure types with all of the following:** • No liquefaction anticipated • No challenging staging or construction issues • No Slope Stability or Settlement concerns • No ground modification expected	**Structures:** • Not satisfying the "No SGR" or "Abbreviated SGR" criteria	**Structures with either an abbreviated or typical SGRs and any of the following:** • Piles set in rock or drilled shaft foundations • Soldier pile or sheet pile walls • Ground improvement or treatment designs/ specifications • Drilled shaft or Vertical piles Subject to lateral loads • Drilled, helical or deadman anchors • Changes to the structure requiring revised design values

It is envisioned that the District project development staff will work with their District geotechnical engineer, and if desired with the selected TSL and SGR consultant team, to concur on the appropriate SGR category and scope. It is expected that the selected SGR will cover all geotechnical aspects required for planning and design, except when a "Geotechnical Design Memorandum" is specified. If during the TSL/SGR review, the scope of the selected SGR category is determined to be insufficient for planning and design, or when additional geotechnical explorations, changes in project scope, or unforeseen geotechnical work/analyses are required, our office will recommend a different SGR category and/or adding a design phase Geotechnical Design Memorandum.

In order to avoid project delays caused by the process of obtaining a supplement, it is recommended that the district include provisional hours in the original SGR agreement to address these cases in a timely manner. It is anticipated these provisional hours would not include man-hours necessary for the Geotechnical Design Memorandum, which we recommend be determined as part of the final design man-hours.

The scope for each SGR category is detailed below to help the Districts and consultants determine the necessary man-hours and properly complete the SGR category selected.

No Structure Geotechnical Report Required

This category can be selected when the criteria noted in the table above are met for a specific project and, therefore, no SGR will be required by the BBS. In this case, the structural engineer will be responsible for all geotechnical aspects of the project during the planning and design phases. In particular, the following are the geotechnical issues which will be considered part of the structural engineer's scope:

- Evaluation of the existing data (borings, plans, pile data, etc.) considering the expected type of substructure and locations to determine the need for further exploration and testing.
- Selection of the proper foundation/wall to be shown on TSL.
- Determination of all geotechnical design parameters and completion of the foundation/wall design satisfying AASHTO and IDOT policies.

Abbreviated Structure Geotechnical Reports

When the project is anticipated to meet the Abbreviated SGR criteria noted in the above table, a scope of work should be developed to address the basic/key geotechnical items necessary for proper planning and design of the structure. The intent is to allow Districts to select a limited SGR category/scope when it is anticipated that extensive geotechnical effort (investigation, analyses, reporting,

etc.) will not be required. The abbreviated report shall be provided on IDOT form BBS 132 with any necessary attachments documenting the geotechnical engineer's professional evaluation of the key areas on the form. In this case, the following describes the Abbreviated SGR content and scope:

- Obtain the general structure plan and elevation configuration, preliminary substructure types, locations, and factored loadings, hydraulic report scour depths, existing borings and plans, and any other information or direction provided by the District or structural engineer. Evaluate the existing data (borings, plans, pile data, etc.) determine the need for further exploration and testing. Obtain additional soils/rock data.

- Indicate the amount of new soil or structure loading that could cause settlement. Estimate the amount and time of any expected settlement. Confirm no further testing, analysis or ground improvement/treatment design is necessary.

- Identifying areas of new slopes (cut or fill). Estimate the proposed slopes' factor of safety. Confirm no further testing, analysis or ground improvement/ treatment design is necessary.

- Report the deepest scour depths indicated in the Hydraulics report for the strength limit state design condition (typically the 100-year event unless lower flows cause deeper scour) and the extreme event design condition (typically the 500-year event unless lower flows cause deeper scour). Apply the non-granular scour depth reductions (per Bridge Manual) to these depths and recommend the strength and extreme event design scour elevations at each substructure.

- Determine the soil seismic site class, and the corresponding 0.2 and 1.0 second accelerations. Confirm that the soils are not liquefiable.

- Confirm the feasibility of the proposed foundation/wall type. Provide the design parameters for the selected foundation/wall type.

- Provide recommendations for only the apparent cost effective foundation type at each substructure:

    1. For piles, provide a Pile Design Table for each substructure indicating all feasible pile types, indicating a wide range of factored pile resistance available, the corresponding nominal required bearings and estimated lengths for each. The range of factored pile resistance available should be selected using the preliminary factored loadings obtained considering the maximum and minimum pile spacing possible. The range of nominal required bearing should extend to the IDOT maximums unless concern for damage suggests they be limited to lower levels.

2. For spread footings, provide factored bearing resistance and unit sliding resistance at various elevations. Confirm no ground improvement/ treatment is necessary.

3. For drilled shafts, provide estimated top of rock, as well as preliminary estimates of skin friction and end bearing values.

4. For box culverts and retaining walls, confirm the feasibility of the proposed wing or wall type and provide the design parameters.

- Obtain the estimated water surface elevation and determine the need for cofferdams, the type of cofferdam(s) (type 1 or type 2) and if a seal coat will be necessary.

- Assess the need and feasibility of using a temporary construction slope, or if sheeting/soil retention will be necessary. When construction slopes are not possible, determine if the temporary sheet piling design charts can be used to provide a design or if a temporary soil retention system will need to be specified. Also, determine if working platform (not more than 2 ft) is required.

- Provide a Subsurface Profile plot of all boring and test data, as well as the logs, as attachments.

Typical Structure Geotechnical Reports

For projects where an Abbreviated SGR is not expected to provide adequate geotechnical input to properly plan and design a cost effective feasible structure, a Typical SGR should be developed. The report format should follow the order of the topics as listed below. The following describes the Typical SGR content and scope:

- Indicate on the cover sheet, the route, section, county, existing and proposed structure numbers, original report date and revised date, as well as the name, email address and phone number of the SGR author.

- Provide information on preliminary structure, layout, factored loadings, wall height, existing borings and plans, and any other information or direction provided by the District or structural engineer.

- Evaluate the subsurface exploration adequacy (existing and new), considering any additional field/lab data to be provided later, and make any recommendations for further exploration/testing necessary for a Geotechnical Design Memorandum, if applicable.

- Indicate the amount of new soil or structure loading that could cause settlement. Provide estimates of the settlement amount and time (t_{90}), as well as, determine whether the estimated settlement is expected to impact the roadway or structure design. When the impact is unacceptable, evaluate the feasibility of various treatment options. When costly treatments or

unacceptable delays in the construction schedule are anticipated, the settlement analysis must utilize soil parameters determined from laboratory testing of undisturbed samples.

- Describe any existing slopes at the site (heights and angles) and indicate any proposed changes such as fills, cuts, or other modification that might affect stability of the slopes. Determine the critical factor of safety (FOS) against slope failure. If the FOS is inadequate, discuss the potential impact of slope failure on the structure and evaluate various treatment options. If costly ground improvement/treatments are recommended, the stability analysis must utilize soil parameters determined from laboratory testing of undisturbed samples.

- Provide seismic data (site class, 0.2 sec and 1.0 sec accelerations, and performance zone). Determine if seismic slope stability or liquefaction analyses are necessary for the site's seismic performance zone. Conduct analyses, if needed, and propose any necessary treatment and/or account for their effects in the foundation design recommendations.

- Report the deepest scour depths indicated in the Hydraulics report for the strength limit state design condition (typically the 100-year event unless lower flows cause deeper scour) and the extreme event design condition (typically the 500-year event unless lower flows cause deeper scour). Apply the non-granular scour depth reductions (per Bridge Manual) to these depths and note any scour countermeasure recommended in the Hydraulics Report or by the structure planner. Provide the strength and extreme event design scour elevations at each substructure to be shown on the TSL. Determine how the final scour depths will impact capacity loss and lateral stability in the foundation design recommendations and indicate that in the SGR.

- For Bridges, the SGR design recommendations should evaluate the feasibility of the various foundation types at each substructure. Discuss any differences between the alternatives in terms of constructability, construction time, equipment access, or performance to allow the planner to select the most cost effective, appropriate foundation type and treatment found feasible in the SGR. Below are the requirements for spread footings, piles and drilled shafts.

  1. When spread footings are considered a feasible alternative, the SGR should provide a table indicating the factored bearing and sliding resistance(s) at the corresponding footing elevation(s) for each substructure unit, considering frost, scour, minimum soil/rock embedment, footing shape, expected loadings or other issues. Indicate any key assumptions used to determine the bearing and sliding resistances provided. When remedial treatments such as removal of unsuitable material and replacement, silt or shale mud slab seal, shear key, or other ground improvement are required to obtain bearing or sliding resistance, the details of these treatments must also

be provided. Sliding Resistance can be provided in terms of the coefficient of friction, adhesion, passive pressure, or minimum embedment in rock to allow the designer to size and detail the footing using the final design loadings.

2. Provide a pile design table for all feasible pile types, indicating a wide range of factored pile resistance available, the corresponding nominal required bearings and estimated lengths for each. The range of factored pile resistance available should be selected using the preliminary factored loadings obtained considering the maximum and minimum pile spacing possible. The range of nominal required bearing should extend to the IDOT maximums unless concern for damage suggests they be limited to lower levels. Also, indicate any key assumptions made in developing the tables such as the assumed pile cutoff elevation, bottom of substructure/ ground surface during driving elevations, etc. The tables should reflect any reductions in resistance resulting from geotechnical losses such as negative skin friction, liquefaction, or scour. Provide possible treatment options to avoid those reductions to allow the planner to determine if their expense is justified by the reduced overall foundation costs. The substructures where any test piles are deemed necessary, the need for metal shoes, the elevation and diameter of any pre-coring, and minimum pile length for scour or pile fixity must be documented. When recommending piles to be drilled and set into rock, provide the same information as for drilled shafts described below, particularly the estimated top of rock, unit factored skin friction and end bearing values.

3. When subsurface conditions, site limitations, or structure type indicate that drilled shafts are feasible and possibly the most cost effective foundation type, design recommendations should be provided. Recommendations shall include preliminary estimated factored skin friction values for each layer and preliminary factored end bearing values at potential tip elevations so the planner can estimate the number, diameter and depth of shafts. In addition, the estimated top of rock elevations at each substructure, feasibility of belling, and effect of downdrag, liquefaction or scour on the vertical and lateral capacities should be addressed.

- For CIP and Precast Box Culverts, the SGR design recommendations should address the potential for differential settlement, wing wall feasibility and constructability. Changes in loading below and adjacent to the proposed box, considering the locations of the existing structure, existing fill, and new fill, should be compared to soil moisture content to provide estimates of differential settlement along the box (between construction stages or between an existing box and extensions) and between fill over and adjacent to the box. The planner will evaluate the box or roadways ability to tolerate the settlement. However, if settlement is too large or abrupt, the SGR should also provide possible treatment options such as settlement collar locations/heights, removal and replacement, waiting period, and preloading. The SGR should

appear cost effective and provide the required site specific foundation design parameters to complete the design. Constructability evaluations should verify that the soils permeability will allow water diversion and construction in the dry. In addition, when silty soils or low strength clay soils are expected to be present at the bottom of the box, a working platform of coarse aggregate up to 24" thick may be recommended to provide a level and stable surface to construct the bottom slab.

- For Three-Sided Structures, the SGR design recommendations should contain the anticipated vertical and horizontal structure loadings on each leg and provide recommendations of feasible foundation types that appear cost effective. The foundation design parameters should be provided for any foundations types considered by the structure planner to be viable options. Provide recommendations regarding wing wall type, water diversion/constructability, and scour depths (total and adjusted) unless counter measures are proposed by the hydraulic engineer.

- For Retaining Walls, evaluate the feasibility of various wall types considering the project design constraints, cross sections, preliminary wall size/location information and subsurface conditions. Discuss wall and foundation types which are feasible and appear cost effective, noting any ground treatment required and provide design parameters for those which the planning engineer would like to consider. When anchored walls are options, discuss the feasibility of using various types of deadman, helical, or permanent ground anchors.

- Discuss construction considerations, including the need for any temporary soil retention versus using soil slopes. Recommend use of cantilevered temporary sheet piling when feasible using the Bridge Manual charts, or note that the IDOT "temporary soil retention system" specification will be necessary. Also, in stage construction fills, recommend use of a temporary geotextile wall or temporary MSE wall where appropriate and feasible. Discuss the need for cofferdam Type 1 or Type 2 based on the estimated water surface elevation at the various substructures. Recommend either a minimum tip elevation that can seal the excavation or the need for a seal coat on Type 2 cofferdams.

- Include only the critical computations to support the major design recommendations made in the SGR to document design parameters, analysis methods, and insight behind how judgments were made. Analyses such as settlement, stability, pile length, shaft resistance, footing capacity, downdrag, scour, liquefaction, removal depth, replacement material strength, wick drain spacing, preloading, and wall feasibility may be provided only when they are the basis for key decisions. Do not include computations when the recommendations are non-controversial or the reasoning is apparent.

- Provide an appendix containing all geotechnical data, such as existing and new soils boring logs, rock core logs, core pictures, Shelby tube test data sheets and other laboratory test results. Develop a "subsurface data profile"

plot of this data, using a format and legible fonts that allow the plot to be incorporated into the contract plans instead of boring logs. The plot shall present the data in columns, sequenced by station, and to scale in the elevation axis, so that variation in soil type, water table, ground surface or rock profile can easily be observed during design and construction. Within the extent of the borings and structure, the approximate existing grade and proposed ground surface lines, as well as bottom of substructure locations and elevations should also be plotted.

Geotechnical Design Memorandum

When the project is anticipated to meet the criteria requiring a Geotechnical Design Memorandum indicated in the above table, the geotechnical scope of work must include design assistance, review, and recommendations by the SGR Geotechnical Design Memorandum author documented in a Geotechnical Design Memorandum. The structural engineer will contact the Geotechnical Design SGR author to discuss and provide all geotechnical design parameters necessary to complete the Final Plans. The following describes the general content and scope of the Geotechnical Design Memorandum:

- For Piles Set in Rock or Drilled Shafts: When the driven pile embedment is insufficient to provide adequate fixity or lateral capacity, often due to deep scour or shallow bedrock, drilling and setting pile in rock or use of drilled shafts are commonly selected by the planner as the foundation of choice. The capacity values provided in the SGR for these foundation types are only preliminary estimates using approximate loadings, foundation configuration and soil/rock testing available prior to TSL completion. The Geotechnical Design Memorandum provides the geotechnical engineer the opportunity to offer less conservative recommendations using more specific information available at the final design phase. Specifically, by using the final loadings, shaft/pile spacing, and diameter provided by the designer, and any additional testing not available during SGR development; the design length can be finalized in this document. The SGR author should also discuss any needs, questions or concerns the designer has and address them in this document.

- For Drilled Shafts or Piles Subject to Lateral Loads, the Geotechnical Design Memorandum author should obtain the lateral loading(s), pile head conditions, and pile/shaft size(s) being considered so lateral load analyses can be performed and provided in the Memorandum. Programs such as COM624, L-Pile, or FB MultiPier which use nonlinear soil springs and the deflection of the pile/shaft, should be used to model the foundation behavior as lateral loading is applied. The analysis should provide the pile head deflection(s) and maximum moment(s) to the designer. If the deflection or moment is unacceptable, the number or size of the pile/shafts may need to be changed and the analysis rerun. Seismic designs typically use assumed pile/shaft fixity to determine substructure loading as well as preliminary pile/shaft

number and size. During the corresponding lateral loading analysis, the results often show different substructure stiffness should be used, which generates revised loading and requires re-analysis until assumed conditions agree with the lateral loading analysis. In cases where the size of pile/shafts are not changing, a series of increasing lateral loadings can be applied to allow the corresponding increasing deflections and moments to be plotted and provided for less iteration. Group effects using the designer's final spacing should also be taken into account during the lateral loading analysis.

- For Ground Improvement, since the SGR or TSL only show the improvement type, the specific limits and/or design of the ground improvement must be provided during the design phase. The final structure and embankment configuration or footing loading should be provided to the Geotechnical Design Memorandum author so that the limits and/or the design can be provided to the designer for inclusion in the plans. In the case of Aggregate Column ground improvement, the estimated treatment limits must be provided. Since the specialty contractor provides the design, the author shall work with the designer to recommend and document the performance requirements of the project (for settlement, bearing capacity, slope stability, etc). To accomplish this, the author should contact vendors and various specialty contractors to draw on their expertise and experience with similar subsurface conditions, to assure the performance requirements can be achieved in the project-specific conditions. The Geotechnical Design Memorandum should provide the minimum required depths and spacing of any treatments such as wick drains, deep soil mixing, jet grouting, etc. Recommendations for removal and replacement or load balancing, with or without light weight fill, should be provided. Specifically, the depths and horizontal limits shall be finalized based on the performance objectives provided by the designer. The acceptable IDOT coarse aggregates shall be provided, and when light weight material is used, the type and limit where it will be required should be specified in the Geotechnical Design Memorandum. The Memorandum shall note the State special provision to be used or assist in the development of a project and treatment specific special provision. The Memorandum should also include recommendations for monitoring instrumentation such as settlement plates, piezometers, etc.

- For Soldier Pile or Sheet Pile Walls, the Geotechnical Design Memorandum author should obtain the final wall heights, slope geometry in front and behind the wall, and any surcharges that may exist from the structure designer. Using this information and the soil boring data (and any new data that was obtained since the TSL/SGR approval) at the site, the author shall develop and provide the design earth pressures in front and behind the wall. The methods, equations and parameters used to obtain the design earth pressures recommendations shall be documented as well, indicating any assumptions made. When deflection is a concern, the Geotechnical Design Memorandum shall provide assistance in computing the wall deflection by providing soil parameters for the designer to use and/or provide analysis

using programs which considers the p-y behavior of soil and rock. For sheet pile walls driven deep or into stiff or dense soils, the Memorandum should document the minimum sheet size that can be driven without damage to the final design tip elevation. Although the designer will determine the tip elevations, pile size and spacing, it is helpful to run some analysis to verify if the recommended pressures will result in a reasonable section modulus, tip elevation and pile spacing in the case of soldier piles.

- For Permanent Ground Anchors, Helical Anchors and Deadman Anchors, the Geotechnical Design Memorandum should provide the proper location(s) and capacity for the anchors to provide adequate global stability. Using the anchor elevations and anchor loadings obtained from the designer, the minimum unbonded length and estimated bonded length shall be provided for Permanent Ground Anchors to assure the anchorage is occurring beyond the design earth pressure failure surface. For Helical Anchors, the minimum extension length and estimated helical length should be provided. For these two anchor types, the Memorandum should recommend an angle of inclination that would put the bonded/helical zone in the strongest soil or rock based on the existing and any soils data. Deadman anchors typically run horizontally, and the Memorandum must locate the anchor to limit the amount of interaction between the design earth pressure failure surface and the deadman passive failure surface. Unlike the other two anchor types, which are designed by the contractor and tested in the field, the deadman anchor type (timber, concrete, sheet pile, drilled shaft, etc.) and factored resistance capacity is completed in the design phase. The Memorandum must then provide the earth pressure to be used, or provide the size based the loading and anchor type determined to be most cost effective. Deadman anchors can be continuous if required, but individual anchors are often more cost effective since they still utilize the soil between deadmen due to arching. The Memorandum should note the standard State special provision to be used or assist in providing a project-specific special provision when necessary.

Submittals and Approvals

For State Projects, not being processed through the Bureau of Local Roads and Streets, one hard copy of the soil borings, abbreviated SGR or typical SGR shall be submitted to the Bureau of Bridges with the TSL Plan as part of the bridge office planning review process. All Reports and Geotechnical memorandums shall contain the authors Illinois Licensed Professional Engineer seal. In addition, an electronic copy of the entire SGR (including appendices, exhibits, attachments, etc.) shall be transmitted as one adobe pdf file using the Illinois.gov file transfer web site. The site can be accessed using the link https://filet.illinois.gov/filet/PIMupload.asp, and by entering "DOT.Geotech.Suggest@Illinois.gov" as the recipient email, your email address, and selecting the SGR file to send will complete the transfer. The SGR file shall

be named using the proposed structure number followed by the letters "SGR" (example: 0162462SGR.pdf). When a Geotechnical Design Memorandum is required, one hard copy shall accompany the final plans submittal and an electronic copy shall be placed in the same ftp transfer directory as one adobe pdf file. The file shall be named using the proposed structure number followed by the letters "GDM" (example: 0162462GDM.pdf).

The Foundations and Geotechnical Unit (FGU) will review the boring data, abbreviated SGR or typical SGR as well as the geotechnical aspects of the TSL plan, as part of the planning review process. An SGR speed letter will be issued to the SGR author with copies to the TSL consultant and District, indicating "Approved as Submitted", "Approved as Revised" or "Returned for Re-submittal". Approved as revised indicates that limited changes were agreed to and an acceptable electronic copy of the revised SGR has been received by our office and will be sent to the TSL consultant. The cover sheet shall always contain both the original date and any revised date(s). If changes cannot be agreed upon or quickly made to the SGR, the SGR will be returned for re-submittal. The Geotechnical Design Memorandum may be reviewed as necessary and assumed adequate unless otherwise noted in the Final Plans approval speed letter.

For local agency projects, the process is similar. However, not all local agency projects are reviewed by the FGU. If the geotechnical information consists only of borings, they should be included in each copy of the Preliminary Bridge Design and Hydraulic Report (PBDHR). If the geotechnical information consists of an abbreviated or typical SGR, two copies shall be included with the PBDHR submittal to the Bureau of Bridges (Local Bridge Unit) through the District Bureau of Local Roads and Streets.

One copy will be forwarded by the Local Bridge Unit to the FGU. The FGU will contact the preparer and request the electronic copy of the SGR be placed on the IDOT "ftp" site as one adobe pdf file, initializing the process described above.

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