KANSAS

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MEMO TO: County Engineers/Road Supervisors/Highway Administrators/Public Works Directors; City Engineers/Street Superintendents; Consultants

FROM: Larry W. Emig, P.E., Chief
Bureau of Local Projects

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DATE: July 8, 2005

SUBJECT: Geotechnical Bridge Foundation Investigation Practice

RE: BLP Memo 05-15
[This is a supplement to the *Project Development Manual for Non-National Highway System Local Government Road and Street Projects and supersedes BLP Memo 02-09*]

Geotechnical bridge foundation guidelines have been in place for projects developed through the Bureau of Local Projects and let to contract by KDOT for a number of years. Initial bridge geotechnical guidelines were issued in 1985. In 2002 the current guidelines were implemented. These guidelines were intended to establish the minimum level of information considered appropriate for a project and to "level the playing field" so that any geologist or engineer proposing to do this work will be performing similar services.

Because we continued to have geology bridge foundation problems several meetings were held to obtain input and recommendations for improving the existing guidelines. We believe the problems were in many cases attributable to inadequate information about the materials on which the bridge was founded. In addition, discrepancies in the amount of information being obtained on projects by different geotechnical firms indicated a need for some clarification of the expectations for these investigations.

In June of this year a meeting was held with representatives from cities, counties, consultants, KDOT and the FHWA to discuss a proposed revised 2002 document. Comments and recommendations have now been incorporated into the final document. The new document will be entitled "Geotechnical Bridge Foundation Investigation Practice" ("Practice"). This document will be considered the standard of care to be followed for all projects utilizing state or federal funds. Deviations will be considered on a case-by-case basis with appropriate documentation.

This new "Practice" document will be effective for all projects where the design or preliminary engineering (PE) agreement was executed after the date of this memorandum. All current projects are encouraged to also follow the revised 2005 "Practice" procedures in the document.

Please contact Ron Seitz or Bruce Filippi at (785)296-3861 if you have any questions.

Attachment

cc: G. David Comstock, P.E., Division of Engineering and Design
Jim Kowach, P.E. Bureau of Design
Lon Ingram, P.E., Bureau of Materials and Research

July 5, 2005

GEOTECHNICAL BRIDGE FOUNDATION INVESTIGATION PRACTICE

The procedures employed in any subsurface exploration program are dependent upon a variety of factors which vary from site to site. The project design objectives and the expected site conditions have a major influence on the subsurface exploration and the development of a drilling plan. The objectives of a drilling plan should be to adequately characterize the subsurface conditions at the site so that: a) The Designer can analyze the conditions to formulate a cost effective solution, and b) Allow the Contractor to prepare a bid that will reflect the work that is anticipated based on the conditions to be encountered. A secondary objective is to obtain maximum subsurface information from a minimum number of exploratory borings.

All geotechnical investigations shall be conducted by or under the direct supervision of a licensed geologist or engineer as provided by the rules and regulations of the Kansas State Board of Technical Professions.

A geotechnical report appropriate for the scope of the project will be prepared to document the findings of all foundation investigations. This report will be submitted to the KDOT Bureau of Local Projects at the time office check plans are submitted.

The following is a list of standard practices for a foundation investigation for State or Federally funded bridge projects developed for funding through the Kansas Department of Transportation. Any deviation from these standard practices should be documented.

1. Perform a site specific investigation for all span bridge and box bridge projects. Subsurface investigation for RCB's smaller than bridge size shall be at the discretion of the designer. The site-specific investigation shall be tailored to the needs of the specific project. Items to be considered include, but are not limited to, type and size of structure, anticipated foundation type, and the designer's/investigator's knowledge of and experience with the local subsurface geology.

2. Make one boring as close as practical to the centerline of each pier bent and abutment for a bridge. All borings shall be documented and located within 3 feet (1 m) horizontally and 0.1 foot (0.03 m) vertically. Additional borings should be made as necessary to develop a continuous soils and geology profile through the structure area including the bottom of the channel. When the drilling plan can be supplemented with additional information, one boring at the centerline of each abutment may be considered to meet the minimum requirement. The supplemental information should be considered only if it is documented and directly supports an accurate soils and geology profile.

A hand-auger or probe should be used near the center of the structure to determine whether rock exists within the depth of the foundation for a bridge size box culvert. Additional probes may be performed at the ends where there is concern that the structure may rest on dissimilar materials along its length. Subsurface investigation for RCB's smaller than bridge size shall be at the discretion of the designer.

3. When approach fill embankments of significant height are used at bridge ends founded on compressible material, make at least one boring at the critical location for each embankment location to determine potential problems associated with settlement and stability of the

embankment. The borings for the embankments can usually be combined with the borings made for the abutments of the structure. Address slope stability and settlement issues in the geotechnical report.

4. Obtain sufficient soil and rock samples from a minimum of one boring to adequately characterize the subsurface materials to a depth appropriate for the loads and the foundation system to be proposed. Soil and rock strengths are required so that the Engineer can calculate bearing capacities for various foundation elements. [Note: This is no less important than for the Engineer to know the strength of concrete or steel so that an analysis can be performed.]

5. Appropriate sampling should be obtained at no more than five-foot intervals in the soil mantle on at least one of the borings where soil thickness and site conditions warrant. The standard penetration test is the minimum acceptable sampling technique in non-cohesive soils. Correlations in cohesive soils and/or bedrock are discouraged unless considerable data exists to justify the results.

6. Field documentation of rock units present at the site are to be characterized as to stratigraphy (geologic nomenclature of each unit), lithology (basic type of material), physical condition (weathering, bedding, color, etc.) and engineering properties (jointing, strength, etc.).

This is an absolute must so that the Engineer knows what conditions were found in the borings. This information can also be used by the Engineer to apply his knowledge and experiences with identified members. These are needed for the Engineer to adequately perform an analysis. Further contractors are familiar with geologic members and know how they can be excavated. This information allows the contractor to submit a cost effective bid.

7. Perform sufficient laboratory testing to characterize subsurface material.

Laboratory testing of material obtained from bore hole samples is essential for the Designer to make an engineering analysis. The analysis is the basis for recommendations and therefore engineering properties are a must. For example, for a spread footing or drilled shaft, an unconfined compression test of the material on which the foundation will be bearing is considered the minimum testing that should be performed. For driven piles that will be driven to refusal, the unconfined compression test is considered optional.

8. Information shown on the boring logs should include the following:

A. Depth and type of all samples obtained.
B. A visual and textural description of the subsurface material.
C. Thickness and geologic nomenclature of each stratum encountered.
D. A record of the Standard Penetration Test as well as any other tests that have been run.
E. An accurate location and top hole elevation for each boring.
F. Stabilized groundwater elevation.

9. Furnish a set of office check plans by the Designer to the Geologist and/or Geotechnical Engineer for review of the items related to the geological investigation. Following the review, the plans should be returned to the Designer with any necessary comments.

10. Perform the geotechnical site investigations under the supervision of a licensed geologist or geotechnical engineer.

11. State the acceptable factor of safety along with the calculated factor of safety.

12. When rock is encountered at shallow depths, make additional transverse borings.

Bedrock encountered at shallow depths may in fact be a "floater" and not a continuous formation of rock. If the bedrock encountered is a "floater" then the amount of rock excavation will be incorrectly identified resulting in a cost overrun or underrun and further the geology of the site will be misrepresented. If a "floater" exists the boring may show soil mantle below, which in Kansas is not geologically possible. Further if the "floater" were designated as the foundation material the contractor would not find a competent layer and there would be additional costs to the owner.

13. Extend borings to a minimum depth of 5 feet (1.5 m) below the bottom of the proposed foundation element.

    The Engineer should know what material lies below the foundation element to ensure that the foundation element is on competent material. Therefore the boring should extend a minimum of 5 feet (1.5 m) below the bottom of the proposed foundation element. It's also necessary so that minor deviations in the excavation limits can be compensated without additional cost.

<u>To provide further guidance, the following "Standard Practice" for Soil Foundation Investigations for Bridges is outlined.</u>

If a new embankment will be placed on a soil foundation, or an existing embankment will be widened or the grade elevated by 10 feet (3 meters), or an existing bridge shortened by the replacement structure; perform the following for a soils foundation investigation:

14. If the depth to bedrock is 10 feet (3 meters) or more, obtain undisturbed soil samples at 5-foot (1.5-meter) intervals throughout the soils profile on at least one abutment location. If the soils vary between the two abutments, perform a similar sampling strategy at the second abutment.

15. Perform consolidation testing and settlement analysis on each recovered sample with a void ratio greater than 0.7. Settlement analysis shall include the anticipated amount of settlement and the time frame for the settlement to occur. As a minimum, perform unconfined compression testing on each recovered sample.

16. Perform slope stability analysis of the proposed configuration. Define the level of analysis, i.e., chart or computer modeling. If the safety factors are questionable, perform more advanced strength testing.

17. Author a report detailing findings of the investigation complete with recommendations. The report shall include a discussion of methodology and calculations for determining the recommendations.

References:

1. ASTM Standards Section 4, Volume 04.08, Soil and Rock (I): D 420-D 5611.
2. Kansas Geological Survey, Bulletin 189, *The Stratigraphic Succession of Kansas.*
3. NHI Course Number 132031 Course Manual, *Subsurface Investigations – Geotechnical Site Characterization.*
4. AASHTO *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, Part 2A and 2B: Tests.
5. FHWA Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans.