GEOTECHNICAL REQUIREMENTS to
AE firms for the preparation of
Full Plans and Specs Solicitation Packages for the
Louisville District COE
04-07

Purpose: The purpose of this document is to outline the geotechnical requirements for the Louisville District's military construction projects (using Full Plans and Specs RFPs) in order to assist the AE in providing direction to the geotechnical subcontractor(s) and prepare the Earthwork specifications 31 00 00.00 06 (formerly 02300L) and the plans.

1.0 GEOTECHNICAL INVESTIGATIONS

1.1 **General**: A geotechnical exploration is performed to obtain specific subsurface data at the site and to provide foundation and earthwork requirements for all projects. The geotechnical exploration shall be performed under the direction of a professional engineer specializing in geotechnical engineering with a minimum of 10 years experience. In addition, a geotechnical ITR member is required to perform Quality Control. The data shall include the depth, thickness, extent, and composition of each stratum and the groundwater conditions. Geotechnical Report shall be submitted at the 30% design stage of design. The purpose of completing the Geotechnical Report at the 30% design stage is to assist in locating structures, to identify potential site development problems, and to determine the foundation system before the design proceeds too far, or down the wrong path.

1.1.1 Submission of Drilling Program. The AE shall complete the "Proposed Geotechnical Exploration Data" sheet (see Exhibit 44 of this document) outlining the proposed scope of exploration and return it as an attachment to the fee proposal before negotiation of the original contract. The character and extent of the exploration shall be designed in consideration of the importance of the structure to be constructed. The "Proposed Geotechnical Exploration Data" sheet is merely a guide for the exploration and is flexible; the final program should develop as information accumulates in order to obtain the greatest amount of useful information in the most cost-effective manner.

1.2 **Method of Exploration**

(a) The field investigation shall consist of a series of soil test borings. The number and spacing of the borings depend upon the type of structure as well as the uniformity of the soil formations. The spacing shall be smaller in those areas subjected to heavy loads and greater in less critical areas. Generally, a minimum of four soil test borings is required for building structures. The borings shall penetrate all soil strata that could shear or consolidate materially under the proposed structural loads. For very heavy or sensitive structures, the borings shall extend to refusal or to bedrock. If design or subsurface conditions warrant, core samples shall be obtained to verify the character and continuity of the refusal material.

Borings located in pavement areas only extend to 5 feet below ground surface or design grade whichever is deeper.

(b) In conjunction with the soil test borings, the standard penetration test shall be performed to obtain disturbed soil samples for classification testing and to get an indication of the density of cohesionless soils and the strength of cohesive soils. Disturbed samples are generally taken every 0.75 m (2 ½ ft) for the first 3 m (10 ft), then every 1.5 m (5 ft) or at each change of material. The static, or Dutch, cone penetration test can be performed to complement the soil test borings. If quantitative laboratory testing is anticipated, relatively undisturbed thin-walled tube samples shall be taken (75 mm (3 in) diameter). Bag samples of auger cuttings shall be collected from pavement and borrow areas to investigate the compaction characteristics of the soil. Groundwater readings shall be taken upon completion of drilling and 24 hours after drilling is completed. In unusual circumstances (e.g., where deep excavations are anticipated in areas of high groundwater), observation wells shall be installed to monitor the groundwater level.

(c) All soil and rock samples taken during the exploration are to be retained by the AE until the Geotechnical Report is approved.

1.3 **Laboratory Testing of Soil Samples**

(a) The laboratory testing program shall be designed to facilitate analysis of the subsurface conditions on the basis of factual data. The program shall include classification tests to identify the soils within the Unified Soil Classification system, measure their physical properties, and enable an estimation of the behavior of the soils based on empirical correlations. Classification testing shall include visual examination, moisture content and Atterberg limits determinations, and when appropriate, grain size analyses and unit weight measurements.

(b) The allowable soil bearing pressure and the expected settlement of the structure must be determined. Quantitative laboratory tests such as the unconfined compression, consolidation, and swell pressure tests shall be performed on undisturbed soil samples to assist in these analyses. The California Bearing Ratio test is performed to quantify the subgrade strength for pavement design; remolded test specimens are prepared IAW the modified Proctor compaction test procedure.

(c) More sophisticated field and laboratory studies shall be performed only if warranted by the complexity of the project. Such field studies include pressure meter measurements, plate bearing tests, and geophysical explorations; laboratory tests include triaxial, direct shear, and permeability tests.

1.4 **Background information:**

For projects within and outside the Louisville Districts traditional military boundaries, such as many of the Reserves Projects, the AE (or his geotechnical subcontractor) shall to contact the project's nearest Military Corps of Engineer District (known as the Servicing Corps

Geographic-District), Geotechnical Engineering Department and the engineering authority (such as the base civil engineer) at the facility the construction will be performed and inquire about standard construction techniques relative to foundations, pavements and earthwork in the area and incorporate applicable requirements into the DB specifications. In addition, Pavement Minimums for projects outside the Louisville District boundaries will be obtained from the project's Servicing Corps Geographic-District. Take this opportunity to get background information relative to experience within the area, such as know swelling soil potential where bell shaped drilled piers are typically used instead of shallow spread footings and where lime stabilization is typically used beneath paving or if known seismic conditions requiring remediation are encountered, etc….

1.5 **Specific Information Relative to Frost Penetration and use of the UFC**:

Paragraph 1-6.6 of UFC 3-310-01: 1-6.6 IBC Section 1805.2.1 – Frost Protection. The minimum depth of footings below the undisturbed ground surface shall be 305 mm (12 inches) or as determined by the local building code, whichever is greater. Protect foundation walls, piers and other permanent supports of buildings and structures from frost as described in the IBC as modified by UFC 1-200-01.

The minimum frost protection depths prescribed by the local building code shall be used where available. Depths to the frost line have been identified in table C-1 for locations within the United States, territories and possessions, and in table D-1 for specific locations outside of the United States. Use the best available locality information at locations where frost depth values are not provided. The design frost depth shall be the lesser of the values prescribed in the local building code or these tables. In some unusual cases, it may be necessary to run thermal models to substantiate that the frost will not penetrate below the foundation. For additional guidance contact the authorizing design agency.

2.0 GEOTECHNICAL REPORT

2.1 General: A foundation analysis is required to show that the type of foundation selected is the most feasible one capable of supporting the structure. The Geotechnical Report must include a narrative describing the design approach and all estimates and assumptions made, as well as soil bearing and settlement calculations IAW the guidelines and general requirements of TM 5-818-1/AFM 88-3, Chap. 7 entitled, "Procedures for Foundation Design of Buildings and Other Structures (except Hydraulic Structures)."

2.2 Specific Requirements: The Geotechnical Report shall be submitted at the 30% stage of design. The written report is prepared after the project information has been reviewed and the collective subsurface information has been analyzed. All conclusions and recommendations shall be supported with appropriate calculations and/or discussion. The report shall include:

(a) a review of information on existing structures in the area;

(b) a review of the area geologic conditions and site topographic features;

(c) a review of the subsurface stratigraphy with the results of all testing conducted;

(d) a general evaluation of the site considering the proposed project and the estimated subsurface conditions;

(e) comprehensive foundation and earthwork recommendations including bearing capacity and settlement calculations and discussions to support the recommended foundation system; and will

(f) Provide backup for any design parameters such as shear strength, earth pressure coefficients, friction factors, subgrade modulus, CBR, etc.

(g) Provide Seismic design criteria (Ss, S1, and site class).

(h) Include Pavement Design Calculations. Pavement designs shall be in accordance with appropriate Army Technical Manuals. Specifically: TM 5-809-12 (slab on grade), TM 5-822-2 (general Provisions) and TM 5-822-5 (flexible and rigid pavement designs and drainage). TM 5-822-12 (Design of Aggregate Surfaced Roads, Airfield Areas, etc) and ETL 1110-1-189 (Geogrids). See attached important notes for Use of TM 5-822-5. PCASE software is also an acceptable method. For Projects in the LRL District boundaries, regardless of the pavement design, a minimum flexible pavement section shall consist of 3.5 inches of asphalt (1.5 inches of surface course and 2 inches of base course) and 8 inches of aggregate subbase and/or base. Regardless of the pavement design, a minimum rigid pavement section shall consist of 6 inches of concrete and 8 inches of aggregate subbase and/or base. Pavement minimums for projects outside the LRL district boundaries will be obtained from the Servicing Corps Geographic-District. The minimum subbase/base can be neglected if the subgrade has a CBR greater than 30. Here is a hot link to Corps Guidance Documents: http://www.usace.army.mil/inet/usace-docs/.

(i) Pavement designs over specific cohesive soil subgrades (CL, CH or ML in accordance with the Unified Soil Classification System (USCS) and soils with 15% or more passing the #200 sieve) require underdrain systems and the pavement sections shall consist of an open graded free draining aggregate that serves as a drainage layer directly below the asphalt or concrete underlain by a densely graded aggregate. The densely graded aggregate must also act as a separation layer such that subgrade soils do not migrate into it. An evaluation of the grain size of the subgrade soils and the proposed aggregate that interfaces with it shall be performed to verify migration will not occur. Alternatively, a geotextile can be used for separation. The drainage layer shall be choked off (if necessary to accommodate paving equipment). Underdrains shall be provided as necessary to collect and remove infiltration from beneath the pavement (typical details shown in Exhibit 44.5 of this document).

(j) Pavement designs over granular soils (less that 15% passing the #200 sieve) shall generally have a single aggregate base consisting of an open graded free draining aggregate. This aggregate must also act as a separation layer such that subgrade soils do not migrate into it. An evaluation of the grain size of the subgrade soils and the proposed aggregate that interfaces with it shall be performed to verify migration will not occur. Alternatively, a geotextile can be used for separation. This aggregate shall be choked off, if necessary, to accommodate paving equipment.

(k) Plans and specifications shall detail all of the specific aggregates proposed in the pavement design per state DOT designations and gradations including the aggregate used to choke off drainage layer aggregates to accommodate paving equipment.

(l) Important Note Regarding Use of TM 5-822-5 for Flexible Pavement Frost Design for the Louisville District Corps of Engineers: When the "Design Index" from Table 3-1 (TM 5-822-5) is less than 4 and an underdrain system is provided for cohesive soils, the applicable "Support Index" from Table 18-3 (TM5-822-5) can be raised to the next highest Support Index (from Table 18-3) to determine the Frost Design Thickness of the pavement. For example, if the "Design Index" (Table 3-1) is less than 4 and an underdrain system is provided because the subgrade is Silty Clay soil (CL in accordance with the Unified Soil Classification System (USCS)) the "Frost Group" from Table 18-2 would be F4. The corresponding Soil Support Index to a Frost Group of F4 is 3.5 (Table 18-3). Because the underdrain system is provided, the next highest Support Index (6.5) can be used to determine the Frost Design Thickness of the pavement.

(m) Important Note Regarding use of TM5-822-5 for Rigid Pavement Frost Designs for the Louisville District Corps of Engineers: When the "Design Index" from Table 3-1 (TM 5-822-5) is less than 4 and an underdrain system is provided for cohesive soils, the applicable Frost Group from Table 18-2 can be modified for use in Figure 18-5 as follows. Frost Groups F3 and F4 can be changed to Frost Groups F2 and S2 and Frost Groups F2 and S2 can be changed to F1 and S1.

(n) If requested, the Geotechnical Report will also include percolation rates, resistively readings, corrosion potential, and shear wave velocities of the subsurface materials.

(o) Soils information obtained from field logs, laboratory tests and geologists' logs shall be presented on the contract drawings in the form of boring plans, final boring logs and explanatory notes. See Exhibit 45 attached to this document for example of boring logs. It is particularly important that complete subsurface information such as dates, elevations, depths to rock, depths to groundwater drilling equipment used, and the presence of unsatisfactory materials, etc. be presented to the Contractor for bidding purposes.

3.0 SOIL COMPACTION AND FOUNDATION EXCAVATIONS (Verify this info gets into the plans and specs)

Soil Compaction shall be achieved by equipment approved by a professional geotechnical engineer. Material shall be moistened or aerated as necessary to provide the moisture content that shall readily facilitate obtaining the compaction specified with the equipment used. Each layer of fill placement shall be no greater than **[usually 8]** inches thick. Compact each layer to not less than the percent of maximum density specified in Table 4-1, determined in accordance with ASTM D-1557}.

Table 4-1 Soil Compaction	
Foundations	**[95%]**
Concrete Work and Pavements	**[90%]**
Landscaping	**[85%]**
Retaining Wall Backfill	**[85 – 90%]**

The requirements shall be verified or modifications recommended by the consulting professional geotechnical engineer in the report whenever engineering, soils or climatic factors indicate the necessity. Any modifications to the stated compaction requirements shall require approval from the COR.

Subgrade suitability (via proof rolling), fill placement and compaction operations shall be observed and tested on a full time basis by a qualified independent testing agency as directed by the contractor's project geotechnical engineer.

During construction, all foundation excavations shall be inspected and approved by the project professional geotechnical engineer prior to placing concrete.

3.0 GUIDE SPECIFICATIONS

3.1 Please modify the Louisville District version of the Earthwork Guide Specifications 31 00 00.00 06 (formerly 02300L)

3.2 For Satisfactory/Unsatisfactory Material in Earthwork Specifications: The AE shall review all subsurface information and make determination of which soil types are satisfactory and which are unsatisfactory with respect to the project requirements.

4.0 PLANS/DRAWINGS

4.1 Data. Where applicable, the allowable soil or rock bearing pressure shall be shown on the plans. This pressure shall be indicated in such a manner that it is understood that the pressure is the design (allowable) pressure used in sizing the foundations and that this pressure is not the ultimate pressure which the soil or rock can withstand.

4.2 Verify that the plans require that "all open foundation excavations be inspected and approved by a licensed geotechnical engineer prior to pouring concrete." We generally see this statement on the "Structural Notes" Plan Sheet under "Foundation Notes."

4.3 Verify the allowable bearing capacity recommended by the geotechnical engineer is used in the structural calculations.

4.4 Verify footing depths are below frost depths recommended in the geotechnical report.

4.5 Verify the pavement design in the geotechnical report is used in the pavement detail. Verify the pavement detail specifies specific aggregates and include underdrain details if underdrains are required.

4.6 Physical Features. Show all physical surface features of the site such as rock outcrops, wet areas (swamps, marshy areas), sanitary landfills, existing pavement condition, etc. This information can influence the design, construction, and bidder's estimate of the earthwork, foundations, and paving features of the project.

Date_____

PROPOSED GEOTECHNICAL INVESTIGATION DATA

FY:_____Project:_____

Location:_____

Project Number:_____Programmed Amount:_____

A-E Name:_____

A-E Location:_____

Geotechnical Consultant:_____

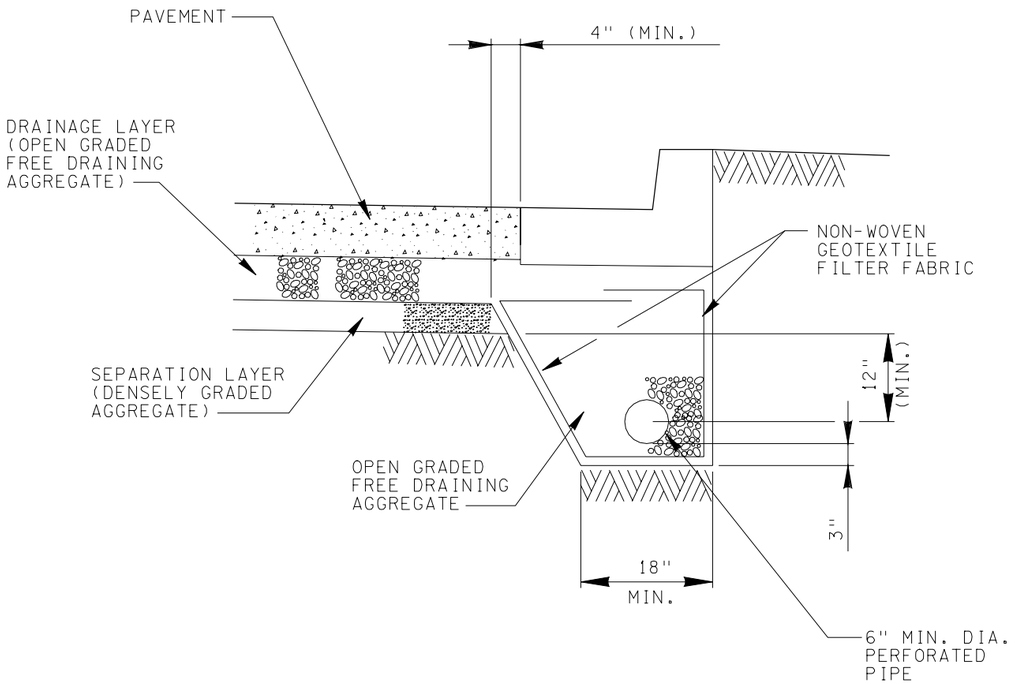
Geotechnical Consultant Location:_____

1. In the space below, draw a footprint of the proposed facility as depicted in the Project Design Brochure/Requirements and Management Plan. Indicate approximate locations where borings, test pits. etc. will be taken. Also, indicate to what approximate depth the borings will be taken (i.e. 20'. 50', refusal, etc.). Approximate dimensions and adjacent major buildings or other site features should be shown.

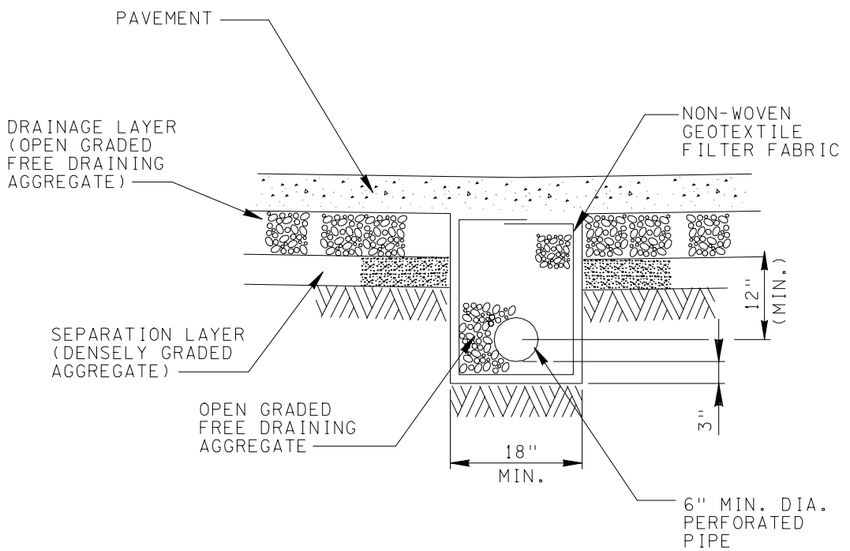
_____

2. Indicate below, by checking the appropriate column, which of the items listed will be included in your proposed geotechnical investigation program (i.e. sampling, testing, etc.)

Yes	No	Qty.	Item Description
			A. Field Sampling
____	____	____	1. Standard Penetration Test
____	____	____	2. Test Pits
____	____	____	3. Bag Samples
____	____	____	4. Shelby Tubes
____	____	____	5. Rock Coring (Size)
			B. Field Testing
____	____	____	1. Pressuremeter
____	____	____	2. Cone Penetrometer
____	____	____	3. Vane Shear
____	____	____	4. Geophysical (e.g. electrical resistivity)
____	____	____	5. Plate Bearing
			C. Laboratory Testing
____	____	____	1. Moisture Contents
____	____	____	2. Atterberg Limits
____	____	____	3. Unit Weights
____	____	____	4. Particle Size Analysis
____	____	____	5. Unconfined Compression Test
____	____	____	6. Consolidation Test
____	____	____	7. Modified Proctor
____	____	____	8. CBR
____	____	____	9. Triaxial
____	____	____	10. Direct Shear
____	____	____	11. Permeability
____	____	____	12. Swell
____	____	____	13. Relative Density



TYPICAL SHOULDER UNDERDRAIN DETAIL



TYPICAL INTERIOR UNDERDRAIN DETAIL

EXHIBIT 44.5

BORING NO. AD-6

PROJECT FT CAMPBELL - ENLISTED BARRACKS
DATE START 11/05/92 COMPLETE 11/05/92
LOCATION: AS SHOWN
DRILLING AGENCY C of E BK 897 PG 80
DRILLER: B HOWARD INSPECTOR: HB
DRILL TYPE: CME 75
DRILL METHOD: 6 5/8" HSA & SPT
THICKNESS OF OVERBURDEN: 15.0
DEPTH CORED INTO ROCK: 0.0
TOTAL DEPTH OF BORING: 15.0'
DIR. OF BORING X VERT. _INCLINED__ DEG

INSTRUMENT INSTALLED NONE
SURFACE ELEVATION: 552.5'
DATUM FOR ELEVATION CONTOUR

ELEV.	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS	DEPTH SCALE (FT)
552.5	SURFACE COVER-									
551.5	No Topsoil - Plowed Hay - Wheat field	T CL				A			SPT-Auto Hammer	1
	Lt tan sl silty CLAY, moist, MED STIFF	CL	4 3 4	1.50	1	J				2
548.5						A				3
	Lt gry to tan mottled sl silty CLAY, moist, STIFF	CL	3 5 9	1.50	2	J	21			4 5
545.5						A				6
	Rusty red to brn sl silty CLAY, moist, STIFF	CL	4 5 6	1.50	3	J	23			7 8
542.5						A				9
	Rusty red sl silty CLAY, moist to damp, STIFF TO V. STIFF	CL	4 6 10	1.50	4	J	30			10 11
						A				12 13
537.5	BORING TERMINATED		6 6 8	1.50	5	J	23		No Groundwater	14

SHEET 1 OF 1

BORING NO. AD-6

EXHIBIT 45