

SECTION 31 00 00

EARTHWORK

08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO T 180 (2017) Standard Method of Test for
Moisture-Density Relations of Soils Using
a 4.54-kg (10-lb) Rammer and a 457-mm
(18-in.) Drop

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600 (2017) Installation of Ductile-Iron Mains
and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 2 2022) Structural Welding
Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M (2024) Standard Specification for Concrete
Aggregates

ASTM C117 (2023) Standard Test Method for Materials
Finer than 75-um (No. 200) Sieve in
Mineral Aggregates by Washing

ASTM C136/C136M (2019) Standard Test Method for Sieve
Analysis of Fine and Coarse Aggregates

ASTM C150/C150M (2022) Standard Specification for Portland
Cement

ASTM C260/C260M (2010a; R 2016) Standard Specification for
Air-Entraining Admixtures for Concrete

ASTM C618 (2023; E 2023) Standard Specification for
Coal Fly Ash and Raw or Calcined Natural
Pozzolan for Use in Concrete

ASTM C989/C989M (2022) Standard Specification for Slag
Cement for Use in Concrete and Mortars

ASTM D698 (2012; E 2014; E 2015) Laboratory
Compaction Characteristics of Soil Using

	Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer than 75- μ m (No. 200) Sieve in Soils by Washing
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³) (2700 kN-m/m ³)
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2974	(2020; E 2020) Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM D4253	(2016; E 2019) Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	(2016) Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4829	(2021) Standard Test Method for Expansion Index of Soils
ASTM D4832	(2016; E 2018) Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D6023	(2016) Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)
ASTM D6103/D6103M	(2017; E 2021) Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and

Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM D8167/D8167M (2023) Standard Test Method for In-Place Bulk Density of Soil and Soil-Aggregate by a Low-Activity Nuclear Method (Shallow Depth)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (2024) Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020 (1983) Methods for Chemical Analysis of Water and Wastes

EPA SW-846.3-3 (1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

1.2 DEFINITIONS

1.2.1 Structural Select Fill

Soil material placed in overexcavation areas to support buildings, walls, pads, and other similar facilities.

1.2.2 Pavement Select Fill

Soil material placed in overexcavation areas to support pavements.

1.2.3 Clay Select Fill

Soil material placed between the building perimeter and the limits of the excavation in overexcavation areas.

1.2.4 Porous Fill

Free-draining material placed for subsurface drainage, as a capillary break, or another specific purpose.

1.2.5 Topsoil

Surface layer of primarily organic soil capable of supporting vegetation growth.

1.2.6 Utility Bedding Material

Fill placed to directly support pipes, conduits, cables, and appurtenant structures. Bedding may also be used to provide a cushion between utilities and bedrock, obstacles, obstructions and other unyielding materials.

1.2.7 Flowable Fill

Fill placed in a plastic or liquid form that flows to near its final placement location with limited assistance and subsequently cures or

solidifies to provide a stable or impermeable barrier.

1.2.8 Satisfactory Materials

Satisfactory materials for fill, backfill, and/or any in-situ soils to remain in place that are not supporting new pavements or building structures comprise any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, CL, CL-ML, CH. Maximum particle size to be no greater than 3 inches in any dimension.

1.2.9 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; roots and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.2.10 Cohesionless Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.11 Cohesive Materials

Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when the fines are plastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.12 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3 inch in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.13 Unstable Material

Unstable materials are too weak to adequately support the utility pipe, conduit, equipment, or appurtenant structure. Satisfactory material may become unstable due to ineffective drainage, dewatering, becoming frozen, excessive loading.

1.2.14 Expansive Soils

Expansive soils are defined as soils that have an expansion index greater than 20 when tested in accordance with ASTM D4829.

1.2.15 Rock

Solid homogeneous interlocking crystalline material with firmly cemented,

laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.16 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below a slab.

1.2.17 Degree of Compaction (Proctor)

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 or ASTM D698 abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with AASHTO T 180-21 paragraph 1.5, Note 1.

1.2.18 Degree of Compaction (Relative Density)

Degree of compaction required for soils with less than 5 percent passing the No. 200 sieve, is expressed as a relative percentage of the maximum index density/dry unit weight and minimum index density/dry unit weight, obtained by the test procedures in accordance with ASTM D4253 and ASTM D4254, respectively, abbreviated as a percent of laboratory relative density.

1.2.19 Borrow

Soil brought to the project site from an external location for the purposes of project construction.

1.2.20 Subgrade

Earth materials directly below foundations and directly below granular base materials in building slab and pavement areas including shoulders.

1.3 SUBSURFACE DATA

Subsurface soil boring logs are shown in project plans. These data represent available subsurface information; however, variations may exist between boring locations.

1.4 CRITERIA FOR BIDDING

Base bids on the following criteria:

- a. Surface elevations are as indicated.

- b. Pipes or other artificial obstructions, except those indicated, will not be encountered.
- c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.
- d. Material character is indicated by the boring logs.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

- Excavation and Trenching Plan; G, PO
- Borrow Plan; G, DO
- Jacking, Boring, and Tunneling Plan; G, PO
- Disposition of Surplus Materials; G, PO
- Preconstruction Meeting; G

SD-03 Product Data

- Flowable Fill Mix Design; G, DO
- Geotextiles

SD-04 Samples

- Geotextiles

SD-06 Test Reports

- Material Test Report; G, DO
- Borrow Site Testing; G, DO
- Pipe Inspection Report; G, DO
- Geotechnical Evaluation Report; G, DO

1.6 QUALITY CONTROL

1.6.1 Geotechnical Engineer

Provide a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions.

The Geotechnical Engineer is responsible for preparing and updating the Excavation and Trenching Plan and Dewatering Work Plan as construction progresses to reflect changing conditions and submit an updated plan if necessary. Submit a monthly Geotechnical Evaluation report, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Contractor is responsible for arranging meetings with the Geotechnical Engineer and Contracting Officer throughout the contract duration.

1.6.2 Qualified Technician

Provide a Qualified Technician to inspect, monitor, sample, and performing field testing. The technician qualifications need to be one of the following: A current National Institute for Certification in Engineering Technologies (NICET) Level II minimum certification in Construction Materials Testing Soils; a Geologist-in-Training with minimum one-year experience; an Engineer-in-Training with minimum one-year experience; a Registered Geologist; or a Professional Engineer.

1.6.3 Lab Validation

Perform testing by a Corps validated commercial testing laboratory or Contractor established testing laboratory meeting the requirements of Section 01 45 00 (or similar number) entitled QUALITY CONTROL and approved by the Contracting Officer. Submit testing laboratory validation for the testing to be performed. Do not permit work requiring testing until testing facilities have been inspected, Corps validated and approved by the Contracting Officer.

1.6.4 Preconstruction Meeting

Conduct a preconstruction meeting at the jobsite at least five business days prior to the start of earthwork operations on the project. The preconstruction meeting is to be arranged by the Contractor and is to follow the written agenda submitted prior to the meeting. The purpose of this meeting is to review the requirements of this specification and the associated plans. The following individuals must be in attendance at this meeting: Contractor's Project Manager and Project Superintendent, earthwork subcontractor's Project Manager and Site Foreman, Contractor's Geotechnical Engineer and Testing Agency, Government Geotechnical Engineer and Civil Engineer, and Government Construction Manager and Engineering Technician.

The minutes of this meeting are to be recorded by the Contractor and published via email within 48 hours to all attendees. The minutes must be re-published within 48 hours via email pending any subsequent comments from the attendees.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Structural Select Fill

Materials classified as GC-SC, GW, GP, GM, SW SP, or SM in accordance with ASTM D2487. Material must be free of organics, have a maximum particle size of three inches, have a plasticity index (PI) less than 18 with less than 35 percent loss on No. 200 sieve, have a liquid limit less than 40,

and have a minimum dry density of 115.0 pcf. The intended purpose of this material is fill in overexcavation areas below building foundations.

2.1.2 Pavement Select Fill

Materials classified as GC-SC, GW, GP, GM, SW SP, or SM in accordance with ASTM D2487. Material must be free of organics, have a maximum particle size of three inches, have a PI value less than 18 with less than 35 percent loss on No. 200 sieve, have a liquid limit less than 40, and have a minimum dry density of 115.0 pcf. The intended purpose of this material is fill in overexcavation areas below new pavement areas.

2.1.3 Clay Select Fill

Materials classified as CL in accordance with ASTM D2487. Material must be free of organics, have a maximum particle size of three inches, have a liquid limit of 35 percent or less, and have a PI of 8 to 15. The intended purpose of this material is to serve as a clay cap on building overexcavation areas.

2.1.4 Porous Fill

Materials containing less than 5 percent passing the No. 200 sieve. Provide the gradation as appropriate for the intended purpose.

2.1.5 Topsoil

Material suitable for topsoil obtained from areas indicated on the drawings is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth.

2.1.6 Capillary Water Barrier

Conform to ASTM C33/C33M for fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve, or coarse aggregate Size 57, 67, or 77.

2.1.7 Utility Bedding Material

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600. Install bedding for plastic piping to spring line of pipe. Utility bedding material may include the following:

2.1.7.1 Class I

Angular graded stone meeting ASTM C33/C33M, Gradation No. 67 shall be from a currently qualified aggregate material source as listed on the ArDOT Qualified Product List.

2.1.7.2 Sand

Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding and backfill.

2.1.7.3 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof identified as GW or GP in accordance with ASTM D2487 for bedding and backfill. Do not exceed maximum particle size of 3 inches.

2.2 FLOWABLE FILL

Design and submit flowable fill mix design to consist of Portland cement, fly ash, and/or slag cement and fine aggregate. Include the dry weights of cementitious material(s); quality and gradation of aggregates in the saturated surface-dry weights along with gradation tests; quantities, types, and names of admixtures; and quantity of water per cubic yard. The minimum unconfined compressive strength to be 100 psi at 28 days in accordance with ASTM D4832. The aggregates in accordance with ASTM C33/C33M Fine Aggregates. Air-entrain fill in accordance with ASTM C260/C260M. The air content to be between 8 and 15 percent in accordance with ASTM D6023. The flow to be between 8 and 12 inches in accordance with ASTM D6103/D6103M. Portland cement to be Type I or II or blended cement in accordance with ASTM C150/C150M. Fly ash to be Class C in accordance with ASTM C618. Provide slag cement in Grade 100 or 120 in accordance with ASTM C989/C989M.

2.3 BURIED WARNING AND IDENTIFICATION MARKERS

Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes	
Red	Electric
Yellow	Gas, Oil; Dangerous Materials
Orange	Telephone and Other Communications
Blue	Water Systems
Green	Sewer Systems
White	Steam Systems
Gray	Compressed Air

2.3.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.3.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.3.3 Detection Wire for Non-Metallic Piping

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.4 MATERIAL FOR RIP-RAP

Provide bedding material and rock conforming to ArDOT for construction indicated.

2.4.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well graded, with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index less than 6.

2.4.2 Rock

Provide rock fragments which ensure permanence in the structure and the environment in which it is to be used. Use rock fragments free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. Provide fragments sized such that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Provide rock with a minimum specific gravity of 2.50. Do not permit the inclusion of more than trace 1 percent quantities of dirt, sand, clay and rock fines.

2.5 BORROW

Provide borrow materials from sources located onsite meeting the requirements of paragraph TOPSOIL. Provide borrow materials from sources located outside of Government property meeting the requirements of STRUCTURAL SELECT FILL and PAVEMENT SELECT FILL and CLAY SELECT FILL.

2.6 GEOTEXTILE

Provide a pervious sheet of polyester, nylon, glass or polypropylene ultraviolet resistant filaments woven, spun bonded, fused, or otherwise manufactured into a non-raveling fabric with uniform thickness and strength. Fabric must have manufacturer certified minimum average roll properties that conform with Section 625 GEOTEXTILE FABRIC of the ArDOT Standard Specifications for Highway Construction. Submit a sample and material product data for all Geotextiles utilized.

PART 3 EXECUTION

3.1 PROTECTION

Perform all work specified in accordance with applicable requirements of the Corps of Engineers publication EM 385-1-1 Safety and Health Requirements Manual. Provide a Geotechnical Engineer to monitor construction activities and to prepare necessary work plans and reports; see paragraph QUALITY CONTROL.

Use equipment of type and size appropriate for the site conditions (soil character and moisture content). Maintenance of exposed subgrades and fills is the responsibility of the Contractor. The Contractor is required to prevent damage by ineffective drainage, dewatering, and heavy loads and equipment by implementing precautionary measures. Repair or replace any defects or damage.

3.1.1 Underground Utilities

Location of the existing utilities indicated is approximate. Physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor is responsible for protecting utilities from damage during construction.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and provide temporary ditches, swales, and other drainage features and equipment as required to keep soils from becoming unstable, prevent erosion, or undermining of foundations. Remove unstable material from working platforms for equipment operation and soil support for subsequent construction features and provide new material as specified herein. It is the responsibility of the Contractor to assess the site conditions to employ necessary measures to permit construction to proceed.

3.1.2.2 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches are not allowed within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Perform control measures by the time the excavation reaches the water level in order to maintain the integrity of the in-situ material.

3.1.3 Shoring and Sheet piling

Submit an Excavation and Trenching Plan to stabilize features, prevent

undermining or unintended horizontal and vertical movement of adjacent structures, and prevent slippage or movement in banks or slopes adjacent to the excavation. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Drawings to include material sizes and types, arrangement of members, and the sequence and method of installation and removal. Calculations are to include data and references used.

3.1.4 Protection of Graded Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.2 BORROW

Select borrow material to meet the requirements and conditions of the fill or embankment for which it is to be used. Obtain borrow material from approved private sources. Submit a Borrow Plan that includes materials to be excavated, stockpile locations, proposed slopes, drainage, and closure. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval.

3.2.1 Contractor Furnished Borrow Area(s)

Obtain approved borrow materials from approved offsite sources. If a borrow source is selected that is not a commercial entity from which soil material is directly purchased, submit a Borrow Plan that includes the borrow source location, geotechnical test results showing the fill material meets the Contract requirements, environmental test results in accordance with paragraph ENVIRONMENTAL REQUIREMENTS FOR OFF-SITE SOIL, and any Federal, State, and local permits required for excavation and reclamation of the borrow area.

3.2.2 Environmental Requirements for Off-Site Soil

Test offsite soils brought in for use as backfill for Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and full Toxicity Characteristic Leaching Procedure (TCLP) including ignitability, corrosivity and reactivity. Backfill may not contain concentrations above appropriate State and EPA criteria, and for hazardous waste characteristics 10 parts per million (ppm) of total petroleum hydrocarbons (TPH) and 10 ppm of the sum of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and pass the TCPL test. Determine TPH concentrations by using EPA 600/4-79/020 Method 418.1. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5030/8020/8260B. Perform TCLP in accordance with EPA SW-846.3-3 Method 1311. Perform hazardous waste characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide borrow site testing for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory evidence), with at least one test from each borrow site. Provide borrow site testing for hazardous waste characteristics (TPH, BTEX

and TCLP) from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring borrow material to project site until Borrow Plan containing environmental test results has been received and approved by the Contracting Officer.

3.3 SURFACE PREPARATION

Remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations. Remove stumps entirely. Grub out matted roots and roots over 3 inches in diameter to at least 18 inches below existing surface.

3.3.1 Stripping

Strip site where indicated on the plans. Strip existing surface materials to a depth of 6 inches below the existing ground surface in areas designated as Topsoil Stripping on the plans. Strip in all areas within the planned limits of disturbance. All stripped materials not suitable for reuse as topsoil will be wasted in specified disposal area. Screen all stripped soils to remove roots and organic materials prior disposal.

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Protect topsoil and keep in segregated piles until needed.

3.3.2 Proof Rolling

Perform proof rolling on exposed subgrade that is unfrozen and free of surface water (wet conditions resulting from rainfall). Perform proof rolling in the presence of the Contracting Officer.

After stripping, excavating, and rough grading to the planned elevation, proof roll the existing subgrade of all building, pavement and embankment locations with six passes of a loaded tandem axle dump truck. Operate the truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2.5 to 3.5 miles per hour. Subgrade materials that exhibit excessive deflection and/or rutting during proof rolling need to be scarified, aerated, and re-compacted to specified density at plus or minus 2 percent of optimum moisture content prior to being considered for remedial action by the Contracting Officer. When proof rolling under buildings, the building subgrade is considered to extend 5 feet beyond the building lines, and make one-half of the passes with the roller in a direction perpendicular to the other passes.

3.3.3 Stockpiling Operations

Place and grade stockpiles of satisfactory and unsatisfactory as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. Do not create stockpiles that could obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.4 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Excavate soil disturbed or weakened by Contractor's operations, and soils softened or made unstable for subsequent construction due to exposure to weather. Use material removed from excavations meeting the specified requirements in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes to minimize surplus material and to minimize additional material to brought on site. Do not excavate below indicated depths except to remove unstable material as determined by the Geotechnical Engineer and confirmed by the Contracting Officer. Remove and replace excavations below the grades shown with appropriate materials as directed by the Contracting Officer.

If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock or as hard/unyielding material, uncover such material, and notify the Contracting Officer. Do not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, and allow sufficient time for classification and delineation of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contracting Officer for the areas of work in which such deposits occur.

3.4.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown. Do not excavate below grades shown. Backfill excessive excavation as directed by the Contracting Officer, with satisfactory, compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed. Do not allow material to be deposited within 4 feet from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.4.2 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended by the manufacturer. Provide vertical trench walls where no manufacturer installation instructions are available. Do not exceed the trench width of 24 inches below the top pipe plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter, and do not exceed 36 inches plus pipe outside diameter for pipe sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.4.2.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate

bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 3 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.4.2.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, notify the Contracting Officer. Following approval, remove such material 6 inch below the required grade and replaced with suitable materials as provided in paragraph FILLING AND COMPACTION.

3.4.2.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with suitable material as provided in paragraph FILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.4.2.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown.

3.4.2.5 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet, or as indicated, from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.4.3 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except those sections requested and if, in the opinion of the Contracting Officer, can be safely and properly installed and backfill. Provide a Jacking, Boring, and Tunneling Plan, signed and sealed by a licensed Professional Engineer that includes a work site layout, methods and procedures, equipment, alignment control, monitoring, and contingency for responding to unplanned movements.

3.4.3.1 Pipeline Casing

Provide new smooth wall steel pipeline casing under existing pavement by the boring and jacking method of installation. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated.

3.4.3.2 Bore Holes

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other fluids in connection with the boring operation.

3.4.3.3 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.4.3.4 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight segmented elastomeric end seals.

3.4.4 Underground Utilities

Perform work adjacent to utilities in accordance with procedures outlined by utility owner. Excavation made with power-driven equipment is not permitted within 2 feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.4.5 Structural Excavation

Following general excavation and rough grading activities, excavate the entire building footprint area and at least 5 feet beyond, 2 feet below bottom of footings. Scarify the exposed surface to a depth of 6 to 8 inches, moisture-condition, and compact to at least 95 percent of laboratory maximum density. For new pavement areas including exterior concrete pads, over-excavate to a minimum of 3 feet below existing grade, scarify, moisture-condition, and compact to at least 95 percent.

Make excavations to the lines, grades, and elevations shown, or as directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata.

Concrete placement is not allowed until footing subgrades have been inspected and approved by the Contracting Officer.

3.4.6 Rock Excavation

Excavate rock encountered in the cut section to a depth of 6 inches below finished grade and replace with satisfactory material.

3.5 SUBGRADE PREPARATION

3.5.1 General Requirements

Shape subgrade to line, grade, and cross section as indicated. Remove unsatisfactory and unstable material in surfaces to receive fill or in

excavated areas, as determined by proof rolling, and replaced with satisfactory materials. Do not place material on surfaces that are muddy, frozen, contain frost, or otherwise containing unstable material. Scarify the surface to a depth of 4 inches prior to placing fill. Step or bench sloped surfaces steeper than 1 vertical to 4 horizontal prior to scarifying. Place 4 inches of loose fill and blend with scarified material. When subgrade is part fill and part excavation or natural ground, scarify to a depth of 8 inches.

3.5.2 Subgrade for Structures, Spread Footings, and Concrete Slabs

Overexcavate to a depth that is 2.0 feet below the bottom of footings and 3.0 feet below bottom of slabs extending horizontal to a minimum of 5.0 feet around the buildings foundation and fill with Structural Select Fill to 6 inches below the bottom of slab. Fill the remaining 6 inches under the slab with Capillary Water Barrier. Structural Select Fill should be placed in 8 inch loose horizontal lifts, moisture conditioned to be within plus or minus two percent of optimum moisture content, and then compacted to 98 percent of Standard laboratory density in accordance with ASTM D698. The top 1.0 foot of Structural Select Fill should be compacted to 100 percent of Standard laboratory density in accordance with ASTM D698. Clay Select Fill should be placed between the building perimeter and the limits of the excavation in 8 inch loose horizontal lifts, moisture conditioned to be within plus or minus two percent of optimum moisture content, and compacted to 90 percent of Standard laboratory density in accordance with ASTM D698. After final rolling, the surface of the subgrade for buildings and pavements must not show deviations greater than 0.05 foot when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

3.5.3 Subgrade for Pavements

Overexcavate the top 3.0 feet of existing material of all paving areas extending a minimum of 3.0 feet around paving perimeters. Fill the excavated area to the bottom of the aggregate base course with Pavement Select Fill. Pavement Select Fill should be placed in 8-inch loose horizontal lifts, moisture conditioned to be within plus or minus two percent of optimum moisture content, and compacted to 95 percent of Modified laboratory density in accordance with ASTM D1557. After final rolling, the surface of the subgrade for buildings and pavements must not show deviations greater than 0.05 foot when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

3.5.4 Subgrade Filter Fabric

Place filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inch diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.6 FILLING AND COMPACTION

Prepare ground surface on which backfill is to be placed and provide

compaction requirements for backfill materials in conformance with the applicable portions of paragraphs for SUBGRADE PREPARATION. Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Fill and backfill to contours, elevations, and dimensions indicated. Compact and test each lift before placing overlaying lift.

3.6.1 Trench Backfill

Backfill trenches to the grade shown. Backfill the trench to 2 feet above the top of pipe prior to performing the required pressure tests. Leave the joints and couplings uncovered during the pressure test.

3.6.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with satisfactory material or initial backfill material.

3.6.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with satisfactory material placed in layers not exceeding 6 inches loose thickness.

3.6.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except where shown or when specified otherwise in the individual piping section, provide bedding for buried piping in accordance with PART 2 paragraph UTILITY BEDDING MATERIAL. Compact backfill to top of pipe to 85 percent of ASTM D1557. Provide plastic piping with bedding to spring line of pipe.

3.6.1.4 Final Backfill

Do not begin backfill until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Bring backfill to indicated finish grade. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 2 feet above sewer lines and one foot above other utility lines need to be free from stones larger than one inch in any dimension. Heavy equipment for spreading and compacting backfill are not to be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; compact remaining area in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Place backfill carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Do not place backfill against foundation walls prior to 7 days after completion of the walls. As far as practicable, bring backfill up evenly on each side of the wall and sloped to drain away from the wall.

Fill the remainder of the trench, except for special materials for buildings and pavements with satisfactory material. Place backfill material and compact as follows:

3.6.1.4.1 Buildings and Pavements

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction. Compact as specified for Structural Fill.

3.6.1.4.2 Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Do not permit compaction by water flooding or jetting. Apply this requirement to all other areas not specifically designated above.

3.6.1.5 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.6.1.6 Displacement of Features

After other required tests have been performed and the trench backfill compacted to 2 feet above the top of the pipe, inspect the pipe to determine whether unexpected or damaging displacement has occurred. Conduct walk-through inspection of pipe sizes larger than 48 inches. Inspect pipes smaller than 48 inches using remote methods using closed circuit television, sonar, or hybrid that can provide a 360-degree inspection of the pipe. Prepare and submit a pipe inspection report consisting of digital video or photos. If, in the judgment of the Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the defects as directed at no additional cost to the Government.

3.6.1.7 Buried Tape And Detection Wire

3.6.1.7.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape above utility line as indicated on the drawings.

3.6.1.7.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping as indicated on the drawings.

3.6.2 Structural Fill Placement

Place fill and backfill beneath and adjacent to structures in successive horizontal layers of loose material not more than 8 inches in depth, or in loose layers not more than 4 inches in depth when using hand-operated compaction equipment. Do not place over wet or frozen materials. Compact to at least 95 percent of laboratory maximum density for the bottom 2 feet of structural fill placement and 100 percent of laboratory maximum density for the top 1 foot of structural fill placement. Perform compaction in such a manner as to prevent wedging action or eccentric loading upon or

other damage to the structure. Moisture condition fill and backfill material to a moisture content that will readily facilitate obtaining the specified compaction.

3.6.3 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.6.4 Porous Fill Placement

Provide under floor and area-way slabs on a compacted subgrade. Place in a single lift and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.6.5 Flowable Fill

Place fill in a manner to completely fill voids in the location indicated. Do not place when atmospheric temperatures are expected to be below 33 degrees F at any time during the 3 day period following placement.

3.6.6 Compaction

3.6.6.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 85 percent of ASTM D1557.

3.6.6.2 Adjacent Areas

Compact areas within 5 feet of structures to 95 percent of ASTM D1557.

3.7 RIP-RAP CONSTRUCTION

Construct rip-rap in accordance with Section 816 FILTER BLANKET AND RIPRAP of ArDOT Standard Specifications for Highway Construction in the areas indicated. Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.7.1 Bedding Placement

Spread filter fabric and bedding material uniformly to a thickness of at least 3 inches on prepared subgrade as indicated.

3.7.2 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above.

3.8 FINISHING/FINISH OPERATIONS

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, frozen or otherwise unstable subgrade.

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except as indicated for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.8.1 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.8.2 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.8.3 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.8.4 Topsoil and Seed

Provide as specified in Section 32 92 19 SEEDING.

3.9 DISPOSITION OF SURPLUS MATERIAL

Remove from Government property all surplus or other soil material not required or not suitable for filling or backfilling, along with brush, refuse, stumps, roots, and timber. Properly disposed of in accordance with all applicable laws and regulations. Prepare plan for Disposition of Surplus Materials to include permissions document to dispose of nonsalable products.

3.10 TESTING

Perform testing as indicated in Table 1. Submit Material Test Reports

within 7 days of tests being completed.

Material Type	Location of Material	Test Method	Test Frequency
Fills and Backfills	Pavement Areas and Site Areas	Density - ASTM D1556/D1556M. When ASTM D6938 or ASTM D8167/D8167M is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556/D1556M.	One test per 250 square yards, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines. If ASTM D6938 or ASTM D8167/D8167M is used, check in-place densities by ASTM D1556/D1556M as follows: One check test per lift for every 2,500 square yards of completed subgrade and aggregate base course.

Material Type	Location of Material	Test Method	Test Frequency
Fills and Backfills	Topsoil/Grass Areas	Density - ASTM D1556/D1556M and ASTM D6938	One test per 750 sq yards
Fills and Backfills	Trench Backfill	Density - ASTM D1556/D1556M and ASTM D6938	One test per 250 linear feet per lift of utility trenches
All fill and backfill	Any	Moisture Content - ASTM D2216	<p>Two tests per day for each type of fill and backfill.</p> <p>Sample taken immediately prior to compaction after moisture conditioning.</p>
All fill and backfill	Any	Moisture Density Relationship - ASTM D1557	<p>One representative test per 750 square yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.</p> <p>Sample to be taken from stockpile or location of placement.</p>

Material Type	Location of Material	Test Method	Test Frequency
All fill and backfill	Any	Relative Density - ASTM D4253 and ASTM D4254	One test per 750 square yards, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines.
All fill and backfill	Any	Gradation - ASTM C136/C136M	One representative test per 750 square yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. Sample to be taken from stockpile or location of placement.

Material Type	Location of Material	Test Method	Test Frequency
Aggregate Base Course	Pavement Areas and Site Areas	Gradation - ASTM C136/C136M	At least one sample of aggregate base course shall be tested in accordance with ASTM C136/C136M. After the initial test, a minimum of one sieve analysis (ASTM C136 and ASTM D422) shall be performed for each 1,000 tons of aggregate base course placed, with a minimum of one analysis performed for each day's run until the course is completed.
All fill and backfill	Any	Atterberg Limits - ASTM D4318	One representative test per 1,000 tons of aggregate base course placed of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. Sample to be taken from stockpile or location of placement.

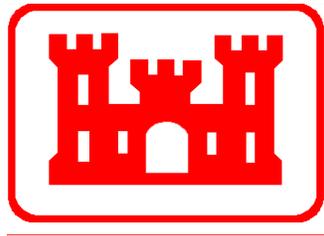
Material Type	Location of Material	Test Method	Test Frequency
Aggregate Base Course	Pavement Areas and Site Areas	Atterberg Limits - ASTM D4318	One liquid limit and plasticity index shall be performed for each sieve analysis per ASTM D4318.
Topsoil	Grass Areas	Organic Content Test - ASTM D2974, Method C	One representative test per 200 lineal feet of embankment.

-- End of Section --

FOUNDATION AND PAVEMENT DESIGN ANALYSIS

F-35 SAPF AND 3-BAY HANGAR

EBBING ANGB, FORT SMITH, ARKANSAS



PREPARED BY

U.S. ARMY CORPS OF ENGINEERS

FORT WORTH DISTRICT

ENGINEERING AND CONSTRUCTION DIVISION

GEOTECHNICAL BRANCH

CESWF-ECG

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FOUNDATION AND PAVEMENT DESIGN ANALYSIS

1. General

The purpose of this report is to provide subsurface information and foundation design considerations, guidance, and requirements for the planned F-35 Special Access Program Facility (SAPF) and 3-bay hangar in Ebbing Air National Guard Base (ANGB) in Fort Smith, Arkansas. Design and construction of the planned facilities will be accomplished under a Design-Bid-Build (DBB) contract.

The planned SAPF will be in the south section of the base near the old airline terminal site. The site is south of the Wing HQ (Building 188) and stormwater ditch, west of Building 182, east of the Ebbing ANGB main gate entry control point, and north of the F-35 Foreign Military Sales (FMS) temporary facilities and the aircraft apron. The planned F-35 3-bay hangar will be located just southwest of the planned SAPF building.

The planned SAPF is a single-story building. The SAPF will have structural steel frame, brick masonry finish walls, concrete decking and a combination pitched standing seam metal and flat roof. The facility will have lightning protection, fire detection and suppression, intrusion detection, and all required supporting facilities to provide a complete and usable facility including utilities, pavements, site improvements, and communication support. This facility will comply with Department of Defense antiterrorism/force protection requirements.

The planned 3-bay hangar is a single-story, steel framed reinforced concrete aircraft hangar with a slab on grade and a steel structure, space framed metal roof. The hangar will provide bay spaces for aircraft maintenance, aircraft corrosion control, and aircraft fuel systems maintenance, an administrative office, storage areas for wash equipment and a radar verification system, shop and unique support space for the F-35 autonomic logistics information system (ALIS), a centralized tool room, compressed air room, a lactation room, bathrooms, electrical, mechanical and telecommunication spaces and a janitor closet. Lightning protection, fire detection and suppression, and intrusion detection will be included. Supporting facilities include utilities, pavements, site improvements, and communication support to provide complete and usable facility. The hangar will comply with Department of Defense antiterrorism/force protection requirements.

Maximum structural loads for the planned SAPF are anticipated to be 60 kips for columns, and 10 and 6 kips per linear foot for strip footings in secure area and other areas, respectively. The maximum structural loading for the planned 3-bay hangar is 250 kips downward and 75 kips uplift.

New concrete roadways (North and South Loop Roads) will be constructed north, east, and south of the planned SAPF. The vehicles and frequencies in the traffic pattern include: 2,281,250 passes of passenger cars (250 daily passes); 2,281,250 passes of large pickup/SUVs (250 daily passes); 18,250 passes of 2 axle 6-tire trucks (2 daily passes); 4,563 passes of P-15 fire truck (0.5 daily passes); 4,563 passes of P-23 fire truck (0.5 daily passes), and 150 passes of AASHTO HS20 semi-trucks (0.5 monthly pass).

New POV parking lots will also be constructed west of the planned building and hangar, outside of the installation fence line. The POV parking lots will be constructed as asphalt concrete pavement and handle daily POV traffic and fire truck traffic on a very rare occasion. The vehicles and frequencies in the traffic pattern include: 2,454,625 passes of passenger cars (269 daily passes); 2,454,625 passes of large pickups/SUVs (269 daily passes), and 300 passes of P-23 fire truck (1 monthly pass).

The roadways and POV parking lots will be designed for a 25-year design life in accordance with UFC 3-250-01 Pavement Design for Roads and Parking Areas dated November 14, 2016.

The F-35 3-bay hangar and apron concrete pavement will be designed for a 20-year design life in accordance with UFC 4-211-01 Aircraft Maintenance Hangars, dated April 20, 2021, and UFC 3-260-02 Pavement Design for Airfields, dated June 30, 2001. Design traffic for Airfield Type – Light as included in Table 3-1 of UFC 3-260-02 will be used for the hangar and apron concrete pavement design (400,000 passes of F-15 C/D and 400 passes of C-17).

Based on grading plans in 65% design, the finished floor (FF) will be El 450 feet for the planned SAPF. The existing ground surface elevation within the planned SAPF footprint ranges from about El. 447 to 448 feet. The finished floor (FF) will be El 451.50 feet for the planned 3-bay hangar. Fills of 0 to 3 feet will be required to reach the final grade.

If project descriptions and assumptions in the section are not correct, CESWF-ECG should be contacted

to determine if the recommendations presented in this report need to be reevaluated.

2. Subsurface Investigation

2.1 Geotechnical Borings

In line with the Scope of Work developed by the U.S. Army Corps of Engineers (USACE), Fort Worth District, a total of twenty (20) borings were drilled by Data Testing, Inc in June, and July 2024. Six borings (B-1 through B-6) were drilled for the planned SAPF to depths of about 45 to 55 feet below existing ground surface, five (5) borings (B-7 through B-11) were drilled for the planned 3-bay hangar to depths of about 50 to 55 feet below existing ground surface, and nine borings (B-12 through B-20) were drilled for the planned pavements to depths of about 15 feet below existing ground surface. The borings were performed using a track mounted Geoprobe 7822DT drill rig and conventional drilling attachments.

The borings were drilled to determine subsurface conditions and to obtain representative soil/rock samples for laboratory testing. The test hole advancement and sample recovery were performed using 4-inch diameter solid stem augers, a nominal 3-inch diameter Shelby tube sampler, and a nominal 2-inch diameter split-spoon sampler and a 2-inch diameter diamond rock core barrel. At plate load testing locations, relatively undisturbed samples were obtained using nominal 5-inch diameter Shelby tube samplers so that two consolidometer samples can be obtained side by side at the same elevation for saturation correction. Samples recovered from the borings were sealed in airtight containers and taken to the laboratory of TEAM Consultants, Incorporated (Arlington, Texas) for testing.

2.2 Dynamic Cone Penetrometer Testing

Dynamic Cone Penetrometer (DCP) testing was performed by Data Testing, Inc for pavement design considerations near each of the pavement boring locations. A DCP consists of a steel rod with a steel cone attached to one end and a sliding single-mass hammer. For this project, the DCP tests were performed by driving the steel cone into the soil using a 17.6-pound sliding hammer dropped from a height of 22.6 inches (574 millimeters) (ASTM D 6951). The more penetration achieved per blow indicates that a “weaker” soil layer was encountered.

The average in-situ California Bearing Ratio (CBR) values derived from the DCP tests were greater than 4 percent. Results of DCP testing are presented in Appendix IV.

2.3 Plate Load Testing

Four plate load tests (PLT-1 through PLT-4) were performed by Data Testing, Inc for airfield concrete pavement design considerations. The plate loading tests were performed in accordance with CRD-C-655. Results of plate load testing are presented in Appendix IV.

The site location is shown on Sheet B-101 and the boring/plate load testing locations are shown on Sheet B-102 in Appendix I. Results of the field investigation are shown on the Logs of Borings sheets, BB-201 through BB-207, in Appendix I.

3. Subsurface Conditions

3.1 General Geology

The Ebbing ANGB is located near the northern boundary of the Arkansas River Valley physiographic province. The Arkansas River Valley is a low-lying province surrounding the valley of the Arkansas River and its major tributaries. The Arkansas River Valley represents the northern extent of the Ouachita orogenic system in Arkansas. Once flat-lying, these Pennsylvanian sedimentary rocks have been compressed into well-developed east-west trending open folds (anticlines and synclines) and faults, which gradually diminish northward into the Ozark Plateau Province. Bedrock strata underlying the Ebbing ANGB are assigned stratigraphically to the McAlester Formation of Middle Pennsylvanian – Des Moinesian series. The McAlester Formation consists of (in ascending order): several hundred feet of shale with thin sandstone and coal (the Lower Hartshorne Coal is just above the base), several hundred feet of shale with a few sandstone beds and coal (Upper Hartshorne Coal) and capped by several hundred feet of shale with a few coal beds. Plant and a few invertebrate fossils have been reported from several horizons within the formation. The McAlester Formation rests conformably on the Hartshorne Sandstone. The unit ranges from about 500 to 2,300 feet in thickness.

3.2 Site Conditions

Subsurface stratigraphy can be divided into three strata. The first stratum consists predominantly of medium to high plasticity lean clay (CL) and fat clay (CH). This stratum was observed in the borings to extend to depths of about 4 to 10 feet below the existing ground surface. The overburden soils had liquid limits ranging from 30 to 82, plastic limits ranging from 16 to 25 (with plasticity indices ranging from 11 to 59), and in situ moisture contents varying from about 7.6 to 29.9 percent.

The second stratum consists of light brown and light gray, soft, weathered shale. The weathered shale had liquid limits ranging from 36 to 47, plastic limits ranging from 16 to 24 (with plasticity indices ranging from 18 to 25), and in situ moisture contents varying from about 3.6 to 26.3 percent. The weathered shale extended to depths of about 25 to 35 feet below the existing ground surface (El 413.1 to 421.4).

The third stratum consists of gray and black, hard, un-weathered shale. The un-weathered shale extended to boring termination depths of about 45 to 55 feet below the existing ground surface. The rock cores of un-weathered shale have recoveries ranging from 80 to 100 percent, and Rock Quality Designation (RQD) ranging from 54 to 100 percent. One exception occurred on a short rock core run between 49.37 and 50 feet in boring B-11, where a RQD value of 0 percent was measured. The low RQD value on this short run was likely due to mechanical break. The rock cores had unconfined compressive strength ranging from about 87 to 275 tons per square foot (tsf), dry unit weight ranging from about 152 to 157 pounds per cubic foot (pcf), and in-situ moisture content of 2 to 2.7 percent.

The boring logs included in Appendix I show the representative site subsurface conditions at the boring locations. The legend on the individual boring logs shows overburden materials as classified in the laboratory using procedures presented in ASTM D 2488. It should be noted that the actual interface between material types might be far more gradual or abrupt than presented; therefore, actual subsurface conditions in areas not sampled may differ from those observed. The nature and extent of variations across the site may not become evident until construction commences, and the actual construction process may alter subsurface conditions as well. If variations become evident at the time of construction, CESWF-ECG should be contacted to determine if the

recommendations presented in this report need to be reevaluated.

3.3 Groundwater Conditions

Groundwater conditions were monitored during drilling and after an observation period of about 24 hours after boring completion. As shown on the boring logs, free water was not encountered during drilling to depths where rock coring started. After approximately 24 hours after boring completion and prior to rock coring, water was measured at depths of about 2.8 to 6.7 below existing grade. Precipitation occurred before 24-hour water measurements were performed in Borings B-3 through B-8 and these water readings are not considered accurate. Most weathered shale samples were dry, and water encountered in the boreholes is believed to be perched water in the overburden soils above the shale bedrock.

It should be noted that groundwater conditions are relative to the time of drilling, annual precipitation, and drainage conditions at the site.

4. Laboratory Testing

4.1 Soil Physical Properties

Representative soil/rock samples recovered from test holes were subjected to laboratory testing for identification, moisture content, grain-size distribution, Atterberg limits, density, shear strength, one-dimensional swell, and controlled expansion-consolidation. The accumulative test results are tabulated and presented in Appendix II. Results of identification and moisture content testing are shown on the boring logs in Appendix I.

Results of laboratory testing performed on samples obtained from the site are also presented graphically in Appendix III as follows: Plasticity characteristics are shown on Plate 1, Plasticity Chart. Moisture content values of representative samples are shown with respect to elevation on Plate 2. Atterberg limits test results are shown with respect to elevation on Plate 3. Dry density values of representative undisturbed clays and rock cores and their corresponding moisture contents are shown with respect to elevation on Plate 4. Compressive strengths of the clay and rock (shale) samples are shown with respect to elevation on Plate 5.

4.2 Shear Strength Testing.

Shear strength characteristics of select clay samples were analyzed in the laboratory using unconsolidated undrained (UU) triaxial compression (ASTM D2805) testing, while shear strength characteristics of rock cores were analyzed using unconfined compressive (UC) strength (ASTM D2166) testing. Tabulated below are the compressive strengths and respective dry densities of the clay and rock (shale) specimens that were tested. Shear strength test results are also presented in Appendix II at the end of this report and summarized on Plate 5 as indicated above.

Boring	Depth, feet	γ_d , pcf	Q_u , tsf	Testing Method	Material Type
B-1	2.5 - 5	104	1.87	UU	Lean Clay
B-1	32 - 42	153.2	102.37	UC	Unweathered Shale
B-1	42 - 52	154.2	86.85	UC	Unweathered Shale
B-2	5 - 7.5	107.1	1.38	UU	Lean Clay
B-2	35 - 45	154.7	220.79	UC	Unweathered Shale
B-2	45 - 55	155.9	159.68	UC	Unweathered Shale
B-3	25 - 35	154.1	149.21	UC	Unweathered Shale
B-3	35 - 45	155.3	134.32	UC	Unweathered Shale
B-4	2.5 - 5	109.4	2.2	UU	Lean Clay
B-4	30 - 40	152.3	139.86	UC	Unweathered Shale
B-4	40 - 50	154.4	144.89	UC	Unweathered Shale
B-5	25 - 35	155.5	274.95	UC	Unweathered Shale
B-5	35 - 45	157.2	194.63	UC	Unweathered Shale
B-6	2.5 - 5	110.6	2.17	UU	Lean Clay
B-6	30 - 40	153.3	210.26	UC	Unweathered Shale
B-6	40 - 50	153.7	121.38	UC	Unweathered Shale
B-7	5 - 7.5	102	1.7	UU	Lean Clay
B-7	30 - 40	155.9	163.92	UC	Unweathered Shale
B-7	40 - 50	156.8	164.04	UC	Unweathered Shale
B-8	2.5 - 5	98.5	1.56	UU	Lean Clay
B-8	7.5 - 9	104.3	1.3	UU	Lean Clay
B-8	35 - 45	154	132.68	UC	Unweathered Shale
B-8	45 - 55	154.9	136.27	UC	Unweathered Shale
B-9	2.5 - 3.5	107.3	0.95	UU	Lean Clay
B-9	37 - 47	156.3	184.03	UC	Unweathered Shale
B-9	47 - 52	155.8	210.64	UC	Unweathered Shale
B-10	35 - 45	155.1	107.78	UC	Unweathered Shale

Boring	Depth, feet	γ_d , pcf	Q_u , tsf	Testing Method	Material Type
B-10	45 - 55	156.2	155	UC	Unweathered Shale
B-11	2.5 - 5.5	112.6	4.8	UU	Lean Clay
B-11	30 - 40	154.4	109.11	UC	Unweathered Shale
B-11	40 - 50	156.7	243.36	UC	Unweathered Shale

4.3 Controlled Expansion-Consolidation Testing.

Controlled expansion-consolidation (CEC) testing was performed on two specimens of the clay soil collected between depths of 2.5 and 5 feet, and 5 and 7.5 feet in boring B-2. The clay specimen collected between 2.5 and 5 feet has a liquid limit of 43, a plastic limit of 17 (PI = 26), and natural moisture content of approximately 22.4 percent. Expansion pressures (p_{exp}) of approximately 0.15 to 0.5 tsf were recorded during CEC testing of the clay specimens. Based on CEC test results, the clay specimens collected have a low to moderate expansion potential ($C_s = 0.02$ to 0.066 ; $p_{exp}/p_0 = 0.64$ to 1.28) and a low to moderate consolidation potential ($C_c = 0.076$ to 0.113). Controlled expansion-consolidation test results are presented in Appendix II at the end of this report.

4.4 One-Dimensional Swell Testing.

One-dimensional swell testing was performed on nine specimens of clays (CL and CH) collected at the site. Specimens were subjected to overburden pressure, inundated with water and allowed to swell freely.

One clay specimen that was tested for Atterberg limits exhibited a liquid limit of 54, plastic limit of 25 and plasticity index of 29. The in-situ moisture content of the nine specimens ranged from about 9.2 to 26.5 percent. Observed swell was negligible for all clay specimens that were tested when subjected to overburden pressure. One-dimensional swell test results are presented in Appendix II at the end of this report.

4.5 Analytical Laboratory Testing.

Analytical laboratory tests consisting of pH and water-soluble sulfate were performed on four representative soil/shale samples. Soil resistivity tests were also performed on five representative soil/shale samples. The results are shown in the following tables.

Boring No	Sample Depth, foot	pH (Test Method: ASTM D4972)	Water Soluble Sulfate, mg/kg (Test Method: EPA 9056)
B-2	0 – 2.5	5.59	153
B-3	2.5 – 5	5.76	533
B-3	10 – 15	7.74	153
B-9	0 - 2.5	4.25	153

Boring No	Sample Depth, foot	In-Situ Condition		Saturated Condition	
		Moisture Content	Soil Resistivity, Ohm.cm	Moisture Content	Soil Resistivity, Ohm.cm
B-3	0 – 5	15.2	2,841	24.9	1,101
B-3	8 - 10	16.5	3,740	23.7	935
B-11	9 – 10	14.2	2,348	27.9	166
PLT-1	0 – 4	16.0	22,858	25.6	7,273
PLT-2	0 - 4	10.3	26,183	26.5	10,390

5. Discussions

The following discussions are provided in support of the foundation and pavement design recommendations and requirements made herein for the planned SAPF and 3-bay hangar and associated pavements. It should be noted that the discussions presented herein are based on the results of the geotechnical field investigation performed by Data Testing, Inc at the project site and laboratory testing program conducted by TEAM Consultants, Inc., as well as engineering studies, and previous engineering experience with similar structures in Fort Smith, Arkansas.

5.1 Foundation Design Considerations.

The near surface soils encountered in the borings are generally medium to high plasticity clays. In addition, the shear strength of near surface clays varies and may be relatively low. To reduce the potential vertical rise (PVR) to about 1 inch and to provide a more uniform foundation and floor slab support some removal and replacement of the existing subgrade soils are required.

The foundation for the proposed facility must meet several criteria. The foundation must be compatible with the superstructure it supports, its movements must be within acceptable tolerances, it must meet functional requirements of the facility and it must be economical. Loading for the proposed SAPF is relatively low (60 kips or less) and shallow spread footings and continuous strip footings shall be used. Loading for the planned 3-bay hangar is moderate (250 kips downward and 75 kips uplift) and straight-shaft drilled pier foundations are recommended to support the planned 3-bay hangar.

5.2 Pavement Design Considerations.

Hangar floor slab and apron pavement designs presented in this report are based on criteria contained in UFC 4-211-01 Aircraft Maintenance Hangars, dated April 20, 2021, and UFC 3-260-02 Pavement Design for Airfields, dated June 30, 2001. Roadway and parking pavement designs are based on UFC 3-250-01 Pavement Design for Roads and Parking Areas dated November 14, 2016.

Based on the results of field plate load and DCP testing and our past experiences with the similar soils, a design modulus of subgrade reaction value of 125 pci and a CBR value of 4 are assigned for the in-situ subgrade.