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USACE / NAVFAC / AFCEC / NASA **UFGS-33 46 16 (May 2018)**

Preparing Activity: USACE **Superseding**
UFGS-33 46 16 (Feburary 2017)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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SECTION 33 46 16

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05/18

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SECTION 33 46 16

SUBDRAINAGE PIPING
05/18

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NOTE: This guide specification covers the requirements for subdrainage systems for drainage of water from under the ground using pipes less than 300 mm 12 inches in diameter.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

1.1 UNIT PRICES

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The paragraph as written contemplates taking bids on a unit-price basis. When it is determined that a lump sum contract may be more advisable, the paragraph will be deleted.

Delete paragraph UNIT PRICES for Navy projects.

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1.1.1 Pipe Subdrains

Measure the length of pipe installed from end to end along the centerlines without any deduction for the diameter of the manholes. Pipe will be paid for according to the number of linear meters feet of subdrains placed in the accepted work. Payment for bedding and [drainage layer] [filter] materials, except geotextiles, will be included in the payment for the pipe subdrain system.

1.1.2 Blind or French Drains

Blind or french drains will be paid for by the linear meter foot and measured from end to end along the centerlines of the completed drains.

1.1.3 Manholes

Manholes to be paid for will be the number of manholes completed with base, rungs or ladders, frames, and covers or gratings (where specified) constructed in the accepted work.

1.1.4 Flushing and Observation Risers

Flushing and observation risers to be paid for will be the number of flushing and observation risers completed with frames and covers (where specified) constructed in the accepted work.

1.1.5 Geotextile

Measure geotextile for payment by the square meter [yard][foot] in place. Measure overlapped joints and seams as a single layer of cloth.

1.2 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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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 M 190	(2004; R 2017) Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M 252	(2009; R 2017) Standard Specification for Corrugated Polyethylene Drainage Pipe
AASHTO M 288	(2017) Standard Specification for Geosynthetic Specification for Highway Applications

ASTM INTERNATIONAL (ASTM)

ASTM A27/A27M	(2020) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2016) Standard Specification for Gray Iron Castings
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A760/A760M	(2015, R 2020) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM A762/A762M	(2019) Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM A798/A798M	(2017) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications
ASTM B745/B745M	(2015) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)

ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3753	(2019) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM F758	(2014) Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

1.3 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding

Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][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-04 Samples

Geotextile

Pipe and Pipe Fittings

SD-06 Test Reports

Geotextile JP-4 Fuel Resistance Test

SD-07 Certificates

Geotextile

Pipe and Pipe Fittings

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

****

NOTE: This time restriction applies to pipe containing normal quantities of ultraviolet (UV) inhibitors such as carbon black or titanium dioxide, in geographic areas receiving normal UV exposure. Delays in installation longer than 6 months, from time of manufacturer to time of installation, may be allowed when the Contractor can show that the pipe has been covered or stored indoors for the duration of the additional delay.

****

Inspect materials delivered to site for damage; unload, and store with minimum handling. Do not store materials directly on the ground. Keep the inside of pipes and fittings sfree of dirt and debris. Keep, during shipment and storage, geotextile wrapped in burlap or similar heavy duty protective covering. Protect the geotextile from mud, soil, dust, and debris. Do not store geotextile materials in direct sunlight. Install plastic pipe within 6 months from the date of manufacture unless otherwise approved.

1.4.2 Handling

Handle materials in such a manner as to ensure delivery to the trench in sound undamaged condition. Carry pipe to the trench.

PART 2 PRODUCTS

2.1 PIPE FOR SUBDRAINS

****

NOTE: Where the type of pipe is to be the Contractor's option, the types that are acceptable should be included in this specification. The inapplicable types of pipe should be deleted.

Perforation and slot sizing is based on embedment gradation, flow requirements, and structural considerations. The embedment material gradation is in turn based on the gradation of the surrounding soil. In order to minimize the migration of fines into the coarser material while maintaining adequate permeability, the following criteria should be met:

All soils (except clays without a sand or silt fraction):

(15 percent size of drainage or filter material)/(85 percent size of material to be drained) = 5 (max)

(50 percent size of drainage or filter material)/(50 percent size of material to be drained) = 25 (max)

(15 percent size of drainage or filter material = 0.4 (max)

All Soils

(15 percent size of drainage or filter material)/(15 percent size of material to be drained) = 5 (min)

(50 percent size of drainage or filter material)/(slot width) = 1.2 (min)

(50 percent size of drainage or filter material)/(hole diameter) = 1.0 (min)

The minimum recommended subdrain pipe diameter is 150 mm 6 inches.

The drawings should indicate which pipes must be perforated (collector pipes) and which pipes must not be perforated (outlet pipes).

****

Submit samples of pipe and pipe fittings, before starting the work. Provide type and sizes of subdrain pipe indicated. Submit certifications from the manufacturers attesting that materials meet specification

requirements. Certificates are required for drain pipe and fittings.

2.1.1 Plastic

Provide plastic pipe containing ultraviolet inhibitor to provide protection from exposure to direct sunlight. Provide pipe with with bell and spigot or solvent cement joints. Provide manufacturer's standard type fittings conforming to the indicated specification.

2.1.1.1 Polyvinyl Chloride (PVC) and Fittings

ASTM D3034, ASTM F949 or ASTM F758, Type PS 46.

2.1.1.2 Corrugated Polyethylene (PE) and Fittings

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NOTE: AASHTO M 252 Type S pipe has an outer corrugated pipe wall and a smooth liner. Type SP pipe is perforated Type S pipe.
****

AASHTO M 252, Type S or SP as indicated.

2.1.1.3 Pipe Perforations

Provide pipe perforations with a minimum water inlet area of 1,060 mm squared per linear meter 0.5 square inch per linear foot and as specified below.

2.1.1.3.1 Circular Perforations in Plastic Pipe

Cleanly cut circular holes not more than 9.5 mm 3/8 inch or less than 4.8 mm 3/16 inch in diameter and arrange in rows parallel to the longitudinal axis of the pipe. Provide pipe with perforations spaced uniformly along rows. Unless otherwise recommended by the pipe manufacturer, provide pipe with rows approximately 38 mm 1-1/2 inches apart and arranged in a staggered pattern so that all perforations lie at the midpoint between perforations in adjacent rows. Space the rows over not more than 155 degrees of circumference. Provide pipe that is not perforated for a length equal to the depth of the socket at the spigot or tongue end and provide perforations that continue at uniform spacing over the entire length of the pipe.

2.1.1.3.2 Slotted Perforations in Plastic Pipe

Cleanly cut circumferential slots so as not to restrict the inflow of water and uniformly spaced along the length and circumference of the pipe. Provide pipe with slots not exceeding 3.2 mm 1/8 inch nor less than 0.8 mm 1/32 inch in width. Provide pipe with individual slot lengths not exceeding 10 percent of the pipe inside nominal circumference on 150 to 200 mm 6 to 8 inch diameter pipe, and 63.5 mm 2-1/2 inches on 250 mm 10 inch diameter pipe. Symmetrically space rows of slots so that they are fully contained in 2 quadrants of the pipe. Center slots in the valleys of the corrugations of profile wall pipe.

2.1.2 Corrugated Steel

****
NOTE: Corrugated steel pipe may be installed in

soils with a pH range of 6.0 to 8.0 provided the resistivity is greater than 2,000 ohm-cm. A bituminous coating should be used when soil or ground-water conditions are at or near these limits.

150 to 200 mm 6 to 8 inch diameter pipe has 38 by 6.5 mm 1-1/2 by 1/4 inch corrugations. Type I pipe has a circular cross section. Type III pipe is Type I pipe that has been perforated. Class 1 perforations are 4.8 mm to 9.5 mm 3/16 to 3/8 inch in diameter with four rows of perforations. Each perforation is located on the inside crests or along the neutral axis of the corrugations.

****

ASTM A760/A760M, Type I or III, as indicated [with a coating conforming to AASHTO M 190, Type A]. Provide Class 1 perforations in Type III pipe. Pipe sheet thickness 1.63 mm 0.064 inch.

2.1.3 Corrugated Aluminum Alloy

****

NOTE: Corrugated aluminum pipe without bituminous coating may be installed in soil with pH range of 5.5 to 8.5 if the resistivity is greater than 500 ohm-cm or 5.0 to 9.0 where the resistivity is greater than 1,500 ohm-cm. This type of pipe should not be installed in material classified as OH or OL according to the Unified Soil Classification System as presented in ASTM D2487. Bare aluminum alloy pipe has satisfactory corrosion resistance in clean granular materials even when subjected to sea water.

Fully bituminous coated corrugated aluminum pipe may be considered in soils where the pH range is 6.0 to 8.0 and resistivity is greater than 2,000 ohm-cm.

150 to 200 mm 6 to 8 inch diameter pipe has 38 by 6.5 mm 1-1/2 by 1/4 inch corrugations. Type I pipe has a circular cross section. Type III pipe is Type I pipe that has been perforated. Class 1 perforations are 4.8 mm to 9.5 mm 3/16 to 3/8 inch in diameter with four rows of perforations. Each perforation is located on the inside crests or along the neutral axis of the corrugations.

****

ASTM B745/B745M, Type I or III, as indicated [with a bituminous coating conforming to AASHTO M 190, Type A]. Provide Class 1 perforations in Type III pipe. Pipe sheet thickness 1.63 mm 0.064 inch.

2.1.4 Precoated Corrugated Steel

****

NOTE: 150 to 200 mm 6 to 8 inch diameter pipe has 38 by 6.5 mm 1-1/2 by 1/4 inch corrugations. Type I pipe has a circular cross section. Type III pipe is Type I pipe that has been perforated. Class 1 perforations are 4.8 mm to 9.5 mm 3/16 to 3/8 inch

in diameter with four rows of perforations. Each perforation is located on the inside crests or along the neutral axis of the corrugations.

****

ASTM A762/A762M, Type I or III, as indicated. Provide Class 1 perforations in Type III pipe.

2.2 GEOTEXTILE

****

NOTE: When geotextile is not used in the drainage system, the requirement for geotextile will be deleted from this specification. When geotextile is used in the drainage system it may be specified either by referencing AASHTO M 288,requirements in Section 31 05 19.13 GEOTEXTILES FOR EARTHWORK (first set of brackets), or by specifying the requirements in this paragraph (remaining brackets).

Design criteria for geotextiles are based on the equivalent opening size (AOS), percent open area (POA), and geotextile permeability (Kg). The AOS is defined as the number of the US Standard Sieve having openings closest in size to the largest openings in the geotextile. The AOS specified should be based on the criteria described below. To perform piping criteria computations, express the AOS as the equivalent US standard sieve opening in millimeters. The AOS can be used for woven and nonwoven geotextiles Where a designer desires to use "percent open area," the percent open area should be based on the criteria below. The percent open area should be used only for woven fabrics. The permeability test can be used for nonwoven and woven geotextiles.

The AOS test is a means of evaluating the piping resistance of a geotextile, and the percent open area test is intended to assure adequate flow through the geotextile and adequate resistance to reduction in permeability over time (clogging). The percent open area test is an indirect test which has been shown to correlate with a woven geotextile's long term permeability. The permeability test measures the ability of the geotextile to pass water without any soil on the fabric. This test does not provide a direct measure of field performance of the geotextile.

Specify geotextile properties which will allow retention of the soil being protected, permit sufficient flow through the fabric, and prevent clogging. The designer should select the AOS, POA, and Kg, based on the following criteria:

Protected Soil Percent Passing 0.075 mm No. 200 Sieve	Piping (a.) Maximum AOS (mm)	Woven Minimum POA	Nonwoven Minimum POA
Less than 5 percent (b.)	D85 (c.)	10 percent	Ks (d.)
5 to 50 percent (b.)	D85	4 percent	Ks
50 to 85 percent	(a.) D85 (b.) Upper Limit on AOS is AOS - 0.212 mm No. 70	4 percent	Ks
More than 85 percent	(a.) D85 (b.) Lower Limit on AOS is AOS - 0.125 mm No. 120		Ks
a. When the protected soil contains appreciable quantities (20 to 30 percent) of material retained on the 4.75 mm, No. 4 sieve, use only the soil passing the 4.75 mm, No. 4 sieve in selecting the AOS of the filter fabric.			
b. These protected soils may have a large permeability and thus the POA of Kg may be a critical design factor.			
c. D85 is the grain size in millimeters for which 85 percent of the sample by weight has smaller grains.			
d. Kg is the permeability of the nonwoven fabric, and Ks is the permeability of the protected soil.			

The AOS requirement should be specified as a range to allow for manufacturing tolerances. The smallest sieve opening size of the AOS range should not be smaller than the openings of a 0.125 mm No. 120 US Standard Sieve. It is preferable to specify a geotextile with openings as large as allowed by the criteria.

Fabric strength requirements vary with intended use and construction procedures. Recommended values are:

Type	Minimum	Test
Tensile	444.8 N 100 lbs	ASTM D4632/D4632M grab test 25 mm 1 inch square and 300 mm 12 inches per minute constant rate at traverse.
Elongation	15 percent	ASTM D4632/D4632M determine apparent breaking elongation.
Puncture	177.8 N 40 lbs.	ASTM D3787 except polished steel ball replaced with a 8 mm 5/16 inch diameter solid steel cylinder with a hemispherical tip centered within the ring clamp.
Tear	177.8 N 40 lbs.	ASTM D4533 trapezoidal tear strength.

Collector pipes should not be wrapped with

geotextile. If the geotextile is used to line a trench, the collector pipe should be separated from the geotextile by a minimum of 150 mm 6 inches of granular backfill material.
****

[Provide geotextile conforming to AASHTO M 288 and meeting the subsurface drainage requirements.] [Provide geotextile meeting the requirements in Section 31 05 19.13 GEOTEXTILES FOR EARTHWORK.][Provide geotextile that is a [woven] [nonwoven] pervious sheet of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polypropylene (PP) or polyester (PET). The use of woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Add stabilizers and/or inhibitors to the base polymer, as needed, to make the filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure. The equivalent opening size (AOS) will be no finer than US Standard Sieve No. [_____] and no coarser than US Standard Sieve No. [_____]. AOS is defined as the number of the US Standard sieve having openings closest in size to the filter fabric openings. [The percent open area will not be less than [_____] percent and not more than [_____] percent. Percent open area is defined as the summation of open areas divided by the total area of the filter fabric and expressed as a percent.] The minimum grab strength will be 160 pounds in accordance with ASTM D4632/D4632M. Provide geotextile with filaments constructed so as to retain their relative position with respect to each other. [Selvage or otherwise finish the edges of the geotextile to prevent the outer material from pulling away from the fabric.] [Provide geotextile that is woven into a width that may be installed as shown without longitudinal seams.]]

Submit samples of geotextile and certifications from the manufacturers attesting that geotextile meets specification requirements.

2.3 [DRAINAGE LAYER] [SUBDRAIN FILTER AND BEDDING] MATERIAL

****
NOTE: The thickness and gradation of the filter material for use with pipe subdrains and blind or french drains will be determined by soil conditions and subsoil drainage requirements. Filter material will be graded in accordance with the requirements of UFC 3-250-01, as applicable. The filter material placed adjacent to perforated pipe will be of a size that will prevent the entrance of any of the filter material into the drain. Graded (composite or layered) filters will be used where specified, and cross sections will be as indicated on the drawings. See UFC 3-250-01 for dimensions of filter and bedding material around pipe. Where site conditions require more than one filter gradation, the drawings will indicate areas of different gradation and the table expanded.
****

[Provide drainage layer material meeting the requirements in Section 32 11 23.23 BASE COURSE DRAINAGE LAYERS][Provide subdrain filter and bedding material composed of washed sand, sand and gravel, crushed stone, crushed stone screenings, or slag composed of hard, tough, durable particles free from adherent coatings. Filter material may not contain

corrosive agents, organic matter, or soft, friable, thin, or elongated particles. Provide filter material that is evenly graded between the limits specified in TABLE I. Gradation curves will exhibit no abrupt changes in slope denoting skip or gap grading. Provide filter materials that are clean and free from soil and foreign materials. Remove and replace filter blankets found to be dirty or otherwise contaminated with material meeting the specific requirements, at no additional cost to the Government.

TABLE I			
	Type I Gradation E 11 ASTM C33/C33M	Type II Gradation 57 ASTM C33/C33M	Type III Gradation [_____] [_____]
ASTM C136/C136M Sieve Size, mm	Percent Passing	Percent Passing	Percent Passing
37.5 1-1/2 inch	--	100	[_____]
25.0 1 inch	--	90 - 100	[_____]
9.5 3/8 inch	100	25 - 60	[_____]
4.75 No. 4	95 - 100	5 - 40	[_____]
2.36 No. 8	--	0 - 20	[_____]
1.18 No. 16	45 - 80	--	[_____]
0.30 No. 50	10 - 30	--	[_____]
0.15 No. 100	0 - 10	--	[_____]

]

2.4 DRAINAGE STRUCTURES

2.4.1 Concrete

Provide concrete and reinforced concrete conforming to the requirements for [21] [_____] MPa [3,000] [_____] psi concrete in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.4.2 Mortar

Provide mortar for connections to drainage structures that is composed of one part by volume of portland cement and two parts of sand. Provide sufficient quantity of water in the mixture to produce a stiff workable mortar. Use water that is clean and free of injurious acids, alkalies, and organic impurities. Use the mortar within 30 minutes from the time the ingredients are mixed with water.

2.4.3 Manholes and Appurtenances

2.4.3.1 Precast Reinforced Concrete Manhole Risers and Tops

ASTM C478M ASTM C478.

2.4.3.2 Precast Concrete Manhole Bases

ASTM C478MASTM C478. Provide bases that allow suitable connection with influent and effluent lines and to provide a suitable base structure for riser sections.

2.4.3.3 Glass Fiber-Reinforced Polyester (FRP)

ASTM D3753.

2.4.3.4 Frames and Covers or Gratings

Except as otherwise permitted, provide frames and gratings, or frames and covers of either cast iron with tensile strength test not less than ASTM A48/A48M Class 25 or steel conforming to ASTM A27/A27M, Class 65-35. Required weight, shape, and size are indicated on the drawings. Frames and covers not subjected to vehicular traffic or storage may be of malleable iron where indicated. Provide malleable-iron frames and covers conforming to ASTM A47/A47M and of the weight, shape, and size indicated.

2.4.3.5 Steel Ladder

Provide a steel ladder where the depth of a manhole exceeds 3.66 m 12 feet. The ladder will be not less than 400 mm 16 inches in width, with 19.1 mm 3/4 inch diameter rungs spaced 304.8 mm 12 inches apart. Provide two stringers that are a minimum 9.5 mm 3/8 inch thick and 50.8 mm 2 inches wide. Adequately anchor ladder to the wall by means of steel inserts spaced not more than 1.83 m 6 feet apart vertically, and install so as to provide at least 152.4 mm 6 inches of space between the wall and the rungs. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

2.5 TESTS, INSPECTIONS, AND VERIFICATIONS

2.5.1 Geotextile JP-4 Fuel Resistance Test

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NOTE: Delete this paragraph when geotextile will not be exposed to JP-4 fuel.
****

Immerse five unaged geotextile samples, 97 to 107 mm by 147 to 157 mm 4 (plus or minus 0.2) by 6 (plus or minus 0.2) inches in JP-4 fuel at room temperature for a period of 7 days. Test each sample for tensile strength and elongation in accordance with ASTM D4632/D4632M. Provide geotextile with a strength in any direction of not less than 85 percent of the strength specified in paragraph GEOTEXTILE.

PART 3 EXECUTION

3.1 EXCAVATION AND BEDDING FOR SUBDRAIN SYSTEMS

Excavate trenches, including the removal of rock and unstable material, in accordance with Section [31 00 00 EARTHWORK] [31 23 00.00 20 EXCAVATION AND FILL]. Bedding material shall be placed in the trench as indicated or as required as replacement materials used in those areas where unstable materials were removed. Compaction of the bedding material shall be as specified for cohesionless material in Section 31 00 00 EARTHWORK.

3.2 MANHOLES AND FLUSHING AND OBSERVATION RISERS

****

NOTE: The details indicating size, shape, materials, thickness of various sections, the finish required, and amounts or reinforcing, if any, for headwalls, and manholes will be shown in the drawings. Also, the shape, size, thickness of sections, kind of materials, and weight for frames and covers for subdrain manholes will be indicated in the drawings. The covers will be designed to have ample strength for the traffic conditions to which they may be subjected. Fixed ladders or ladder rungs will be provided for manholes 3.6 m 12 feet or deeper measured from top of grate to invert of outlet pipe.

****

3.2.1 Manholes

Install manholes complete with frames and covers or gratings at the locations and within the limits and sizes indicated. Construct manholes of one of the materials specified for manholes in paragraph DRAINAGE STRUCTURES. [Completely fill precast concrete manhole joints so that they are smooth and free of surplus mortar or mastic on the inside of the structure.] Use either precast or cast-in-place concrete manhole bases.

3.2.2 Flushing and Observation Risers

Install flushing and observation riser pipes with frames and covers at the locations indicated. Construct risers of non-perforated [plastic] [or] [galvanized] [bituminous coated] [corrugated metal] pipe. Join riser pipes to the subdrain system as indicated.

3.3 INSTALLATION OF GEOTEXTILE AND PIPE FOR SUBDRAINS

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NOTE: Outlets for subdrains, if possible, within reasonable costs, will be designed so that severe rainstorms will neither submerge the drains nor back up water into the drains. Where outlets are not subject to backwater or flooding, the outlets will be provided with grates or heavy screens to prevent acts of vandalism or entrance by rodents. If suitable outlets for blind or french drains into pervious strata of gravel or sand with a lower water table are not obtainable, pipe outlets may be required. The perforated pipe will extend into the filter material of the blind or french drain a sufficient distance to provide ample waterway openings for the particular drain and non-perforated pipe will extend through the impervious material to a suitable outlet. Outlets subject to flooding will be provided with suitable and properly installed check valves or flap gates. If outlet pipes are necessary for blind or french drains, and are to be paid for as a separate item, such requirement will be clearly specified, giving the various kinds and sizes of pipe required.

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3.3.1 Installation of Geotextile

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NOTE: When geotextile is not used in the drainage system, the requirement for geotextile will be deleted from this specification.

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3.3.1.1 Trench Lining and Overlaps

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NOTE: The strength properties of most geotextiles composed of plastic materials are adversely affected by ultraviolet rays. Consequently, the geotextile should be exposed to sunlight as little as possible, and preferably should be covered the same day as installed. When geotextile is used to separate the drainage layer or filter material from the soil being drained, the gradation ratios of filter material to protected soil given in UFC 3-230-06A, do not apply; however, size the geotextile to filter the protected soil.

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Grade trenches to be lined with geotextile to obtain smooth side and bottom surfaces so that the geotextile will not bridge cavities in the soil or be damaged by projecting rock. Lay the geotextile flat but not stretched on the soil, and secure it with anchor pins in accordance with manufacturer's instructions. Overlap at least 150 to 300 mm 6 to 12 inches, and secure with anchor pins along the overlaps.

3.3.2 Installation of Pipe for Subdrains

3.3.2.1 Pipelaying

Install pipe in accordance with the manufacturer's recommendations. Thoroughly examine each section of pipe before being laid; do not use defective or damaged pipe. Do not lay pipe when the trench conditions or weather is unsuitable for such work. Remove water from trenches by sump pumping or other approved methods. Lay the pipe to the grades and alignment as indicated. Bed the pipe to the established gradeline. Center perforations on the bottom of the pipe. Lay bell-and-spigot type with the bell ends upstream. Approval of all in-place pipes by the Contracting Officer is required prior to backfilling.

3.3.2.2 Jointings

3.3.2.2.1 Perforated Corrugated Metal Pipe or Bituminous Coated, Perforated Corrugated Metal Pipe

Securely fasten together the sections of perforated corrugated metal pipe or bituminous coated, perforated corrugated metal pipe standard connecting bands furnished by the manufacturer of the pipe.

3.3.2.2.2 Bituminous Coated or Uncoated Corrugated Aluminum Pipe

If aluminum pipe is to be connected to dissimilar metal, insulate the

connection by bituminous coating or other nonconductive material. Securely fasten standard joints between corrugated aluminum pipe with standard connecting bands furnished by the manufacturer of the pipe.

3.4 INSTALLATION OF [DRAINAGE LAYER][FILTER] MATERIAL AND BACKFILLING FOR PERFORATED SUBDRAINS

After perforated pipe for subdrains has been laid, inspected, and approved, place [drainage layer] [filter] material around and over the pipe to the depth indicated. Place the [drainage layer] [filter] material in layers not to exceed 200 mm 8 inches thick. [Saturate by flooding.] [Thoroughly compact each layer using mechanical tampers or rammers.]

3.5 INSTALLATION OF BEDDING AND BACKFILL FOR NON-PERFORATED SUBRAIN OUTFALL PIPE

3.5.1 Plastic Pipe

Place and compact pipe embedment for plastic pipe in accordance with ASTM D2321. Use Class IB or II embedment materials.

3.5.2 Corrugated Metal Pipe

Place and compact bedding ans structural backfill for corrugated metal pipe in accordance with ASTM A798/A798M. Use structural backfill materials classified by ASTM D2487 as either GW, GM, GP-GM, GW-GM, GC, GP-GC or SW.

3.6 INSTALLATION OF AND BACKFILLING FOR BLIND OR FRENCH DRAINS

Place filter material as indicated and compact as specified for cohesionless materials in Section [31 00 00 EARTHWORK] [31 23 00.00 20 EXCAVATION AND FILL]. Extend filter material to a suitable outlet or to an outlet through a pipeline as indicated. Place and compact overlying backfill material as specified in Section [31 00 00 EARTHWORK] [31 23 00.00 20 EXCAVATION AND FILL].

-- End of Section --