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USACE / NAVFAC / AFCEA / NASA UFGS-31 05 22 (April 2006)  
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Preparing Activity: USACE (CW) Replacing without change  
UFGS-02378 (August 2004)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 9 October 2006

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### SECTION 31 05 22

#### GEOTEXTILES USED AS FILTERS 04/06

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NOTE: This guide specification covers the requirements for furnishing all plant, labor, equipment, and materials, except materials specified to be furnished by the Government, and performing all operations required for furnishing, hauling, and placing the geotextile, complete, as specified and shown, and maintaining the geotextile until placement of the granular filter material, bedding material, and/or riprap cover is completed and accepted.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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## PART 1 GENERAL

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NOTE: This guide specification is to facilitate the preparation and review of specifications for procurement and installation of woven and nonwoven geotextiles as filter material. It is based on field performance and the laboratory testing of a limited number of geotextiles. Geotextiles possess greatly varying engineering properties and physical characteristics. Such variations require the designer to decide which testing method and what test criteria are necessary for each application.

The apparent opening size (AOS), percent open area (POA), geotextile permeability (Kg), and strength test described in the specifications that follow are physical property tests. While it is acceptable to specify minimum thickness value where it governs performance, it is inappropriate to use thickness to identify a geotextile. Result of these tests are used to judge the acceptability of a geotextile for a particular use. Prospective geotextile suppliers should furnish these test results before their geotextile will be considered for use, or before contract specifications are adjusted to permit the use of geotextiles whose properties are outside the limits imposed by this guide. For severe soil conditions and/or for a project using a large amount of geotextiles, the specifications should require that the applicable tests be run during construction, either at a specific frequency or upon demand of the Contracting Officer. For projects requiring small amounts of geotextiles under normal soil conditions the physical properties of the geotextile supported by written authentication from an authorized representative of the manufacturers may be accepted.

The actual life of geotextiles is not known, and their use in inaccessible areas must be considered carefully. Therefore geotextiles should not be used as filter material in toe drains, buried collector system, relief wells, or within any portions of embankments. Caution is advised in using geotextiles on the upstream face of earth dams or to wrap permanent piezometers.

Geotextiles are basically inert materials for typical civil engineering applications. However certain applications may expose the geotextile to chemical or biological activities that could drastically influence the filtration properties of the geotextile. Specific site conditions should be reviewed, and if such conditions exist, testing and specifications should be written to overcome it.

Geotextile strength requirements vary with intended use and construction procedures. Experience has shown that when a heavier non-woven geotextile is used, the bedding material can often be reduced in thickness or completely eliminated. TABLE I, RECOMMENDED GEOTEXTILE STRENGTH REQUIREMENTS IN SI (ENGLISH) UNITS (1) presents the most important geotextile strength properties. It should be noted that the strength requirements listed are only a guideline to the minimum values required for survivability. Specific applications may require additional testing.

Filter design criteria for geotextiles are based on the apparent opening size (AOS, which is designated as EOS in the previous guide specification), percent

open area (POA, for woven only), geotextile permeability (Kg), and an appropriate percent passing size of the soil. For piping analysis computations, AOS must be expressed as an equivalent U.S. standard sieve opening in millimeters. To assure adequate resistance to reduction in permeability over time (clogging) and sufficient long term flow through the soil/woven geotextile system, POA criteria, as expressed in the next note, can be used.

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TABLE I  
RECOMMENDED GEOTEXTILE STRENGTH REQUIREMENTS IN METRIC UNITS (1)

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GEOTEXTILE USE	STRENGTH REQUIREMENTS (MINIMUM VALUES)			
	ASTM D 4632 TENSILE (N)	ASTM D 4355 ULTRAVIOLET DEGRADATION AT 500 HRS PERCENT	ASTM D 4833 PUNCTURE (N)	ASTM D 4533 TEAR (N)
RIPRAP SLOPE PROTECTION FILTER WITH GREATER THAN 102 mm BEDDING	515	50	180	180
RIPRAP SLOPE PROTECTION WITHOUT BEDDING	900	50	360	180
DRAINAGE TRENCH	515	50	180	110
SLAB DRAIN	515	50	180	110
ARTICULATED MATTRESS OR INTERLOCKING BLOCK SLOPE PROTECTION FILTER	515	50	180	180

(1) Strength values are for the weaker principal direction.

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TABLE I  
RECOMMENDED GEOTEXTILE STRENGTH REQUIREMENTS IN ENGLISH UNITS (1)

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GEOTEXTILE USE	STRENGTH REQUIREMENTS (MINIMUM VALUES)			
	ASTM D	ASTM D 4355	ASTM D	ASTM D

	4632 TENSILE (lbs)	ULTRAVIOLET DEGRADATION AT 500 HRS PERCENT	4833 PUNCTURE (lbs)	4533 TEAR (lbs)
RIPRAP SLOPE PROTECTION FILTER WITH GREATER THAN 4 INCHES BEDDING	115	50	40	40
RIPRAP SLOPE PROTECTION WITHOUT BEDDING	200	50	80	40
DRAINAGE TRENCH	115	50	40	25
SLAB DRAIN	115	50 50	40 40	25 25
ARTICULATED MATTRESS OR INTERLOCKING BLOCK SLOPE PROTECTION FILTER	115	50	40	40

(1) Strength values are for the weaker principal direction.

The designer must specify geotextile properties which will allow retention of the soil being protected, permit sufficient flow through the textile, and prevent clogging. The designer should select the AOS, POA, and Kg, based on criteria in TABLE II, GEOTEXTILE FILTER DESIGN CRITERIA. The AOS requirement should be specified as a range, to allow for manufacturing tolerance. It is preferable to specify a geotextile with opening as large as allowed by the design criteria. The smallest sieve opening size of the AOS range should not be smaller than the U.S. Standard sieve size No. 120 (0.125 mm).

TABLE II  
GEOTEXTILE FILTER DESIGN CRITERIA

PROTECTED SOIL (1) (PERCENT PASSING NO. 200 SIEVE)	SOIL (2) PIPING	COEFFICIENT OF PERMEABILITY (3)			
		WOVEN		NON-WOVEN	
< 5	$0_{95}/D_{85} < 1$	POA	10%	Kg	5Ks
5 TO 50	$0_{95}/D_{85} < 1$	POA	4%	Kg	5Ks
50 TO 85	$0_{95}/D_{85} \leq 1$ $0_{95} < 0.212 \text{ mm}$ (No. 70 U.S.)	POA	4%	Kg	5Ks

TABLE II  
GEOTEXTILE FILTER DESIGN CRITERIA

PROTECTED SOIL (1) (PERCENT PASSING NO. 200 SIEVE)	SOIL (2) PIPING  sieve)	COEFFICIENT OF PERMEABILITY (3)	
		WOVEN	NON-WOVEN
$q_{95}/D_{85} < 1$	$0_{95} \leq 0.125$ (No. 120 U.S. sieve)	Kg 5Ks	

(1) Recent experiences have indicated that  $0_{95}$  (i.e. AOS) increased with increasing relative density,  $D_r$ , and it is higher for uniform soil than well graded soil of similar density and average particle size.

(2) If the protected soil contains appreciable quantities of material retained on the No. 4 U.S. sieve use only the soil passing the No. 4 U.S. sieve in selecting the  $0_{95}$  of the geotextile.

(3) Kg is the permeability of the geotextile and Ks is the permeability of the protected soil.

Satisfactory geotextile performance is greatly dependent on the field preparation of the surface of the protected soil and the installation procedure.

The following information is related to TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE. Geotextile calculations should be based on procedure from an accepted reference. Worst placement conditions should be considered since stresses generated during installation often exceed post construction stresses.

(1) The requirement of permittivity (as defined in ASTM D 4491) should be chosen in such a manner that the permeability of the geotextile should always be at least five times greater than the permeability of the adjacent soil during the life of the protected earth structure.

(2) The minimum seam strength listed in TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE is based on the tensile strength of the parent geotextile material. Seam strength can also be considered as not less than 90 percent of the unaged grab tensile strength of the geotextile in the applicable direction.

FIGURES described below are available only in the published copy of this Guide Specification.]

Figure 1. Correct geotextile placement for current acting parallel to bank or for wave attack on the bank.

Figure 2. Placement of geotextile on bank subject to streamflow action. Revetment materials have not yet been placed on the geotextile.

Figure 3. Geotextile on bank subject to wave attack showing placement of vertical-wall key trench at toe and top bank. Revetment materials have not yet been placed on geotextile.

Figure 4. Key trench design used when soil conditions do not permit construction of vertical walls.

The Designer shall comply with the requirements of the following Regulatory Requirements:

U.S. DEPARTMENT OF INTERIOR, BUREAU OF RECLAMATION -  
7-2071 (6-48), (1992) Design Standard No. 13,  
"Embankment Dams", Chapter 19, "Geotextile"

U.S. DEPARTMENT OF INTERIOR, BUREAU OF RECLAMATION:

EM 1110-2-1601, (1991) "Hydraulic Design of Flood  
Control Channels"

EM 1110-2-1906, (1970) Laboratory Soil Testing,  
Appendix V, "Grain-Size Analysis", paragraph 2d  
"Procedure", subparagraph (1)(g)

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## 1.1 REFERENCES

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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 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.



ASTM INTERNATIONAL (ASTM)

ASTM D 123	(2003) Terminology Relating to Textiles
ASTM D 4354	(1999) Sampling of Geosynthetics for Testing
ASTM D 4355	(2002) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D 4491	(1999; R 2004) Water Permeability of Geotextiles by Permittivity
ASTM D 4533	(2004) Trapezoid Tearing Strength of Geotextiles
ASTM D 4632	(1991; R 2003) Grab Breaking Load and Elongation of Geotextiles
ASTM D 4751	(2004) Determining Apparent Opening Size of a Geotextile
ASTM D 4833	(2000e1) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D 4873	(2002) Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D 4884	(1996; R 2003) Strength of Sewn or Thermally Bonded Seams of Geotextiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1601	(1994) Hydraulic Design of Flood Control Channels
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1.2 UNIT PRICES

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NOTE: If Section 01 22 00.00 10 MEASUREMENT AND PAYMENT is included in the project specifications, this paragraph title (UNIT PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01270.  
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1.2.1 Geotextiles

1.2.1.1 Payment

Payment will be made at the contract unit price and will constitute full compensation to the Contractor for providing all plant, labor, material, and equipment and performing all operations necessary for the complete and satisfactory installation of the geotextile. The following items are included in the contract unit price for Geotextiles and will not be counted a second time in the process of determining the extent of geotextile

placed: Material and associated equipment and operation used in laps, seams, or extra length; securing pins and associated material, equipment, and operations; and material and associated equipment and operations used to provide cushioning layer of sand or gravel or both to permit increase in allowable drop height of stone. No payment will be made for geotextiles replaced because of waste, contamination, damage, repair, or due to Contractor fault or negligence.

#### 1.2.1.2 Measurement

Installed geotextiles will be measured for payment in place to the nearest [\_\_\_\_\_] square meter feet of protected area as delineated in the drawings.

#### 1.2.1.3 Unit of Measure

Unit of measure: [\_\_\_\_\_] square meter feet.

### 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 to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

## SD-04 Samples

### Geotextile

If requested, submit geotextile samples for testing to determine compliance with the requirements in this specification. When required, submit samples a minimum of [\_\_\_\_\_] [60] days prior to the beginning of installation of the same textile. Upon delivery of the geotextile, submit duplicate copies of the written certificate of compliance signed by a legally authorized official of the manufacturer. The certificate shall state that the geotextile shipped to the site meets the chemical requirements and exceeds the minimum average roll value listed in TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE. Upon request, supply quality control and quality assurance tests for the geotextile. All samples provided shall be from the same production lot as will be supplied for the contract, and shall be the full manufactured width of the geotextile by at least 3 m 10 feet long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least 1.5 m 5 feet. Samples submitted for testing shall be identified by manufacturers lot designation. For needle punched geotextile, the manufacturer shall certify that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

## SD-07 Certificates

### Geotextile

[Submit the manufacturer's certification of the geotextile material.] [All brands of geotextile and all seams to be used will be accepted on the basis of mill certificates or affidavits. Submit duplicate copies of the mill certificate or affidavit signed by a legally authorized official from the company manufacturing the geotextile. The mill certificate or affidavit shall attest that the geotextile meets the chemical, physical and manufacturing requirements stated in this specification.]

## 1.4 SHIPMENT, HANDLING, AND STORAGE

### 1.4.1 Shipment and Storage

Only approved geotextile [rolls][, panels, ][\_\_\_\_\_] shall be delivered to the project site. All geotextile shall be labeled, shipped, stored, and handled in accordance with ASTM D 4873. No hooks, tongs, or other sharp instruments shall be used for handling geotextile.

## PART 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 Geotextile

##### 2.1.1.1 General

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**NOTE: Nonwoven geotextiles are suitable for**

filtering fine-grained soils whereas woven or  
nonwoven are suitable for well graded granular soils.

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The geotextile shall be a [woven][non-woven] pervious sheet of plastic yarn as defined by [ASTM D 123](#). The geotextile shall equal or exceed the minimum average roll values listed in TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE. Strength values indicated in the table are for the weaker principal direction.

TABLE 1  
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES		TEST METHOD
GRAP STRENGTH	N			<a href="#">ASTM D 4632</a>
SEAM STRENGTH	N			<a href="#">ASTM D 4632</a>
PUNCTURE	N			<a href="#">ASTM D 4833</a>
TRAPEZOID TEAR	N			<a href="#">ASTM D 4533</a>
PERMEABILITY	cm/sec			<a href="#">ASTM D 4491</a>
APPARENT OPENING SIZE	U.S. SIEVE			<a href="#">ASTM D 4751</a>
PERMITTIVITY	sec <sup>-1</sup>			<a href="#">ASTM D 4491</a>
ULTRAVIOLET DEGRADATION	Percent	50 AT 500 Hrs	50 AT 500 Hrs	<a href="#">ASTM D 4355</a>

TABLE 1  
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES		TEST METHOD
GRAP STRENGTH	lb			<a href="#">ASTM D 4632</a>
SEAM STRENGTH	lb			<a href="#">ASTM D 4632</a>
PUNCTURE	lb			<a href="#">ASTM D 4833</a>
TRAPEZOID TEAR	lb			<a href="#">ASTM D 4533</a>
PERMEABILITY	cm/sec			<a href="#">ASTM D 4491</a>
APPARENT OPENING SIZE	U.S. SIEVE			<a href="#">ASTM D 4751</a>
PERMITTIVITY	sec <sup>-1</sup>			<a href="#">ASTM D 4491</a>
ULTRAVIOLET DEGRADATION	Percent	50 AT 500 Hrs	50 AT 500 Hrs	<a href="#">ASTM D 4355</a>

#### 2.1.1.2 Geotextile Fiber

Fibers used in the manufacturing of the geotextile shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polamides. Stabilizers and/or inhibitors shall be added to the base polymer if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. The edges of the geotextile shall be finished to prevent the outer fiber from pulling away from the geotextile.

#### 2.1.2 Seams

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**NOTE: Most geotextiles are manufactured in widths of 1.8 to 5.5 m (six to eighteen feet), but to reduce the number of overlaps, wider sections may be produced by attaching narrow sections together. Pre-assembled sections of 11-m (36-foot) widths or more are preferred to keep the number of overlaps to a minimum.**  
\*\*\*\*\*

The seams of the geotextile shall be sewn with thread of a material meeting the chemical requirements given above for geotextile yarn or shall be bonded by cementing or by heat. The sheets of geotextile shall be attached at the factory or another approved location, if necessary, to form sections not less than [ ] meter [ ] feet wide. Seams shall be tested in accordance with method **ASTM D 4884**. The strength of the seam shall be not less than 90 percent of the required grab tensile strength of the unaged geotextile in any principal direction.

#### 2.1.3 Securing Pins

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**NOTE: The use of security pins should be restricted as much as possible since holes in geotextile allow pin boils to form and remove material from beneath geotextile and cause failure of system.**  
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The geotextile shall be secured to the embankment or foundation soil by pins to prevent movement prior to placement of revetment materials. Other appropriate means to prevent movement such as staples, sand bags, and stone could also be used. Securing pins shall be inserted through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Securing pins shall be removed as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes maximum spacing between securing pins depends on the steepness of the embankment slope. The maximum pins spacing shall be equal to or less than the values listed in TABLE 2, MAXIMUM SPACING FOR SECURING PINS. When windy conditions prevail at the construction site, the number of pins should be increased upon the demand of the Contracting Officer. Terminal ends of the geotextile shall be anchored with key trench or apron at crest, toe of the slope and upstream and downstream limits of installation.

TABLE 2  
MAXIMUM SPACING FOR SECURING PINS

EMBANKMENT	SPACING, meter
STEEPER THAN 1V ON 3H	0.6
1V ON 3H TO 1V ON 4H	1.0
FLATTER THAN 1V ON 4H	1.5

TABLE 2  
MAXIMUM SPACING FOR SECURING PINS

EMBANKMENT	SPACING, feet
STEEPER THAN 1V ON 3H	2
1V ON 3H TO 1V ON 4H	3
FLATTER THAN 1V ON 4H	5

## 2.2 INSPECTIONS, VERIFICATIONS, AND TESTING

### 2.2.1 Manufacturing and Sampling

Geotextiles and factory seams shall meet the requirements specified in TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE.

[Conformance testing shall be performed in accordance with the manufacturers approved quality control manual.][ Geotextiles shall be randomly sampled in accordance with [ASTM D 4354](#) (Procedure Method A). Factory seams shall be sampled at the frequency specified in [ASTM D 4884](#).]

### 2.2.2 Site Verification and Testing

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**NOTE: The need for, and amount of, site verification testing should be based on the severity of site conditions and the amount of textile being placed.**

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Samples shall be collected at approved locations upon delivery to the site [at the request of the Contracting Officer][in accordance with [ASTM D 4354](#) (Procedure Method B)][at a frequency of once per [9290 square meters](#) [100,000 square feet](#)]. Samples shall be tested to verify that the geotextile meets the requirements specified in TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE. Samples shall be identified by manufacturers name, type of geotextile, lot number, roll number, and machine direction. Testing shall be performed at an approved laboratory. Test results from the lot under review shall be submitted and approved prior to deployment of that lot of geotextile. Rolls which are sampled shall be immediately rewrapped in their protective covering.

## PART 3 EXECUTION

### 3.1 SURFACE PREPARATION

Surface on which the geotextile will be placed shall be prepared to a relatively smooth surface condition, in accordance with the applicable portion of this specification and shall be free from obstruction, debris, depressions, erosion feature, or vegetation. Any irregularities will be removed so as to insure continuous, intimate contact of the geotextile with all the surface. Any loose material, soft or low density pockets of material, will be removed; erosion features such as rills, gullies etc. must be graded out of the surface before geotextile placement.

### 3.2 INSTALLATION OF THE GEOTEXTILE

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NOTE: This paragraph describes installation in an open area and on generally planar surfaces. For installation of geotextiles in drainage systems or about collector pipes, additional specification requirements may need to be added. The use of geotextiles to wrap collector pipes should be avoided whenever possible.

Minimum overlaps should be specified at 300 to 450 mm (12 to 18 inches) depending on the specified orientation of the overlap to the direction of wave attack, velocity, or seepage. For under-water placement, minimum overlap should be 900 mm (3 feet).

Geotextiles will bridge small surface features in the slope and allow erosion to occur beneath the geotextile. Surface drainage should be directed away from the top of slope to prevent erosion under the geotextile. Surface flow should be brought downslope at controlled points such as lined ditches.

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#### 3.2.1 General

The geotextile shall be placed in the manner and at the locations shown. At the time of installation, the geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

#### 3.2.2 Placement

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NOTE: The placement of the geotextile relative to this paragraph may follow the following general procedures. (FIGURES referenced in this note are available only in the published copy of this Guide Specification).

(1) For current acting parallel to the bank the geotextile shall be placed with the long dimension parallel to the current (Fig. 1a). Geotextile placement shall be started from the bottom up with upper strips overlapping lower strips, and the

upstream strips shall overlap the downstream strips. The overlaps at the end of strips shall be staggered at least 1.5 m. (5 feet). Revetment and geotextile materials shall be extended at least below the mean low water to minimize erosion at the toe (Fig. 2). If construction schedule permits, a period of low streamflow shall be selected for the geotextile installation.

(2) When revetment material and geotextile filter are selected to protect against wave attack, the geotextile strips shall be placed vertical to the slope of the bank with the upper strips overlapping the lower strips (Fig. 1b). The geotextile shall be keyed at the toe to prevent uplift or undermining (Fig. 3). The key trench shall be located below the mean low water to prevent erosion of the soil adjacent to the trench. When it is not possible to maintain vertical trench walls, the geotextile shall be keyed to an excavated trench with stable slopes (Fig. 4). A key at the top of the bank shall be installed where there is an overbank drainage problem.

Allowing the geotextile to drape or be free of high tensile stress during placement will require larger quantities of geotextiles than the actual slope length.

\*\*\*\*\*

The geotextile shall be placed with the long dimension [parallel] [perpendicular] to the [centerline of the channel] [shoreline] [trench] and laid smooth and free of tension, stress, folds, wrinkles, or creases. The strips shall be placed to provide a minimum width of [ ] mm [ ] inches of overlap for each joint. The placement procedure requires that the length of the geotextile be approximately [ ] percent greater than the slope length. The Contractor shall adjust the actual length of the geotextile used based on initial installation experience. Temporary pinning of the geotextile to help hold it in place until the [bedding layer] [riprap] is placed shall be allowed. The temporary pins shall be removed as the [bedding] [granular material] [riprap] is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Design protection of riprap should be in compliance with EM 1110-2-1601. Trimming shall be performed in such a manner that the geotextile shall not be damaged in any way.

### 3.3 PROTECTION

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NOTE: All geotextiles can be damaged if stone is dropped on it from a height greater than 900 mm (3 feet). Some geotextiles can be damaged with lesser drop heights. When stone is heavy and angular it may cause punctures in the geotextile even if dropped from a height of 300 mm (1 foot). Tension in the geotextile must be minimized to prevent puncture.

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The geotextile shall be protected at all times during construction from contamination by surface runoff and any geotextile so contaminated shall be removed and replaced with uncontaminated geotextile. Any damage to the geotextile during its installation or during placement of [granular filter materials] [bedding materials] [riprap] shall be replaced by the Contractor at no cost to the Government. The work shall be scheduled so that the covering of the geotextile with a layer of the specified material is accomplished within [\_\_\_\_\_] [7] calendar days after placement of the geotextile. Failure to comply shall require replacement of geotextile. The geotextile shall be protected from damage prior to and during the placement of riprap or other materials. [ This may be accomplished by limiting the height of drop to less than 300 mm 1 foot, by placing a cushioning layer of sand or gravel on top of the geotextile before placing the material, or other methods deemed necessary. Care should be taken to ensure that the utilized cushioning materials shall not impede the flow of water.] Before placement of riprap or other materials, the Contractor shall demonstrate that the placement technique will not cause damage to the geotextile. In no case shall any type of equipment be allowed on the unprotected geotextile.

### 3.4 PLACEMENT OF CUSHIONING MATERIAL

Placing of cushioning material shall be performed in a manner to insure intimate contact of the geotextile with the prepared surface and with the cushioning material. The placement shall also be performed in a manner that shall not damage the geotextile including tear, puncture, or abrasion.

On sloping surfaces the cushioning material shall be placed from the bottom of the slopes upward. During placement, the height of the drop of riprap material shall not be greater than 300 mm 12 inches. Any geotextile damaged beneath the cushioning material shall be uncovered as necessary and replaced at no cost to the Government.

### 3.5 OVERLAPPING AND SEAMING

#### 3.5.1 Overlapping

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NOTE: In general, overlapping is sufficient where the primary purpose is to hold the material in place during installation. However, where the design requires the geotextile to resist tensile stresses, seams should be sewn. A 300-mm (12-inch) overlap specified in this section is considered minimum for all cases. The Contractor has the option of field sewing instead of overlapping.  
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The overlap of geotextile [rolls] [panels] [\_\_\_\_\_] shall be [300] [600] [900] [\_\_\_\_\_] mm [12] [24] [36] [\_\_\_\_\_] inches. Appropriate measures will be taken to insure required overlap exists after cushion placement.

#### 3.5.2 Sewn Seams

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NOTE: The Designer must specify appropriate seam test requirements. ASTM D 1683, the previously used test standard, has been discontinued with no replacement designated.  
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High strength thread should be used such that seam test should conform to ASTM D 4884. The thread shall meet the chemical, ultraviolet, and physical requirements of the geotextile, and the color shall be different from that of the geotextile. The seam strength shall be equal to the strength required for the geotextile in the direction across the seam. Overlapping J-type seams are preferable over prayer-type seams as the overlapping geotextile reduces the chance of openings to occur at the seam. Double sewing shall be used specially for field seams to provide a safety factor against undetected missed stitches.

### 3.6 [FIELD TESTING

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NOTE: The need for field testing should be based on  
the size and importance of the project. Field  
testing should be performed if the geotextile will  
be in tension.  
\*\*\*\*\*

Geotextile [in tension ]shall be field tested.]

-- End of Section --