United States Department of Agriculture
Soil Conservation Service
P.O. Box 2890
Washington, D.C.
20013

December 19, 1991

DESIGN NOTE NO. 24

SUBJECT: ENG - GUIDE FOR THE USE OF GEOTEXTILES

Purpose. To distribute Design Note (DN) No. 24, Guide for the Use of Geotextiles.

Effective Date. Effective when received.

Geotextiles are becoming widely used in the design and construction of soil and water conservation practices and structures. They can be effective in improving drainage, protecting against piping or erosion, and providing reinforcement or separation of fill materials. Proper selection of materials and types of geotextiles are very important. Careful evaluation of the location and intended function is required, along with an evaluation of strength, opening size, net open area, durability, and other factors.

This design note discusses the uses of geotextiles, their physical properties, and some important design and construction considerations. Also included are some factors that should be considered in the decision to use geotextiles and in the design and construction practices that will ensure proper function. Tables containing the requirements for geotextiles from material specification 592 are repeated here for convenience.

Filing Instructions. File with other design notes and guide materials related to design and construction procedures for geotextiles.

Distribution. This design note will be of interest to engineers, technicians, and others who may be involved with the design, construction, or selection of geotextiles in soil and water conservation practices or structures. Initial distribution is as indicated in a survey for design notes (shown on the reverse side). Additional copies may be obtained by ordering DN-24 from the Consolidated Forms and Distribution Center, 3222 Hubbard Road, Landover, Maryland 20785.

EDGAR H. NELSON
Associate Deputy Chief
for Technology

Enclosure

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GUIDE FOR THE USE OF GEOTEXTILES

November 1991

U.S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service
Engineering Division

DESIGN NOTE

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GUIDE FOR THE USE OF GEOTEXTILES

CONTENTS

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GUIDE FOR THE USE OF GEOTEXTILES

1. INTRODUCTION. Geotextiles are made to be versatile for solving problems associated with soil and water conservation work. They can be very effective in improving drainage, protecting against piping or erosion and providing reinforcement or separation of fill materials. Proper design is necessary to ensure adequate function or service. They are manufactured from materials that deteriorate with time depending on the use environment, installation period and/or method of pre-installation storage. Careful evaluation of the location and intended function is necessary to determine if geotextiles are appropriate and of the type that should be used. Properties that must be evaluated include strength, apparent opening size (AOS) for filtering, net open area, and durability (length of life) under storage, construction and installed conditions. The actual life of geotextiles is not known and their use in inaccessible areas must be considered carefully.

Geotextiles have a great variety of engineering properties and physical characteristics. The designer must recognize the testing methods and the test results that are significant to the intended application. Tests are used to evaluate the acceptability of geotextiles for a particular use, and it is important to verify the physical properties of the specified geotextile.

The use of geotextiles in SCS engineering practices is generally defined by four functional applications; drainage, filtration, reinforcement and separation.

a. Drainage. The ability of a geotextile to convey fluid within the plane of the fabric. The thicker nonwoven geotextiles have this capacity, while woven and heat bonded nonwoven geotextiles do not.

b. Filtration. The ability of a geotextile to allow fluid flow thru the fabric plane but prevent the movement of soil particles. Permeability of the fabric is an important design consideration, as is the size and distribution of the openings in the geotextile.

c. Reinforcement. The ability of a geotextile to distribute the loading imposed on soil, develop tensile strength and bridge over voids, cracks, or gaps.

d. Separation. The ability of a geotextile to keep two different materials apart during installation and subsequent use that would otherwise tend to mix and compromise the intended integrity.

2. SPECIFIED USES. The following uses have been identified and specifications developed to meet each as indicated in Table 1, Requirements for Woven Geotextiles and Table 2, Requirements for Nonwoven Geotextiles.

a. Slope Protection. Utilizes both the filtration and the separation functions. In some soft soil conditions, the reinforcement function may also be used. Important performance properties included adequate permeability to permit subgrade drainage; proper size and distribution of openings for soil retention, and sufficient strength to withstand installation stresses. Installation stresses are directly related to the height of rock drop allowed and the use of sand or gravel to protect the geotextile and cushion the rock drop. A rough fabric surface to promote bond with the base soils and resistance to sliding by the rock is also a factor to be considered in assessing the adequacy for use in slope protection. Nonwoven needle punched geotextiles are superior in this feature.

b. Subsurface Drainage. The functions involved in subsurface drains are filtration and separation. Adequate permeability and size and distribution of opening size are important properties. Strength is mostly a factor in the installation of the geotextile. Flexibility and the ability of the fabric to fit closely to the surface irregularities is important.

c. Road Stabilization. The functions involved in this use are separation, reinforcement, and, to a lesser degree, filtration. Some permeability is required, but the key factors are the ability to take tensile loads with uniform deformation. Backfill or covering procedures are also important for the geotextile to function as intended.

3. PHYSICAL PROPERTIES.

a. Tensile Strength - This property is measured by a grab test method. It determines the effective strength of the fabric when subjected to forces that tend to pull the fabric apart. (ASTM-D4595)

b. Elongation - The stretching or elongation of a geotextile when measured at the point of failure or rupture of the fabric during the tensile strength test. (ASTM-D4595)

c. Bursting Strength - The force or pressure required to rupture fabric by an expanding diaphragm over which the fabric is clamped. (ASTM-D3786)

d. Puncture - The force required to penetrate or rupture a fabric with a small rounded projectile. (ASTM-D4833)

e. Apparent Opening Size (AOS) O_{95} - The approximate size of the largest particle that would effectively pass through the geotextile. (ASTM-D4751; Formerly EOS, O_{95})

f. Percent Open Area (POA) - For a woven geotextiles, the summation of the open area of an observed unit area of fabric divided by the total area, expressed in percent. (CWO-02215-86 Corp of Engineers)

g. Permittivity - Permeability or hydraulic conductivity of a geotextile divided by the geotextile thickness. The volumetric flow rate of water per unit cross sectional area per unit head under laminar flow conditions, normal to the plane of the fabric. (ASTM-D4491)

h. Transmissivity - The volumetric flow rate of water per unit width of a geotextile specimen per unit gradient in a direction parallel to the plane of the specimen. (ASTM-D4716)

i. Ultraviolet Light Resistance - A measure of the potential for the deterioration of tensile strength in the fabric due to exposure to ultraviolet light and water. (ASTM-D4355)

j. Minimum Average Roll Value - A value in testing that is two standard deviations less than the mean value. This means that the results of approximately 98% of the tests taken would be equal to or greater than the minimum average roll value.

4. DESIGN CONSIDERATIONS. For filtration, the designer must specify geotextile properties that will allow retention of the soil being protected while allowing sufficient flow through the geotextile, and prevent clogging. Woven geotextile requires more critical evaluation and analysis than nonwovens in most applications and the following guidelines are recommended for determining requirements.

a. Woven Geotextiles. The AOS is critical when the geotextile fabric serves as a filter, or if seepage gradients are significant. It is also critical if the geotextile fabric protects underlying soils from erosion, and flow or splash characteristics could affect the underlying base soil. The AOS test provides a means of evaluation the retention characteristics of a geotextile while POA provides a measure of flow through the geotextile and adequate resistance to any reduction in permeability over time (clogging). POA is used only for woven geotextiles. Since the POA data is obtained from laboratory evaluations without soil covering the geotextile, it is an index test and doesn't provide a direct measure of field performance. The base soil gradation must be known. If the base soil has particles larger than the #4 sieve, the gradation of the base soils must first be regraded. (See SCS Soil Mechanics Note-1). The following recommendations then apply to the regraded soil.

(1) Soils with more than 85% passing the #200 sieve. Do not use a woven geotextile adjacent to these soils. A layer of fine sand must be used between the base soil and the geotextile if a woven geotextile is to be used. The AOS of the geotextile is then determined considering the sand used as the base soil.

(2) Soils with 51-85% finer than the #200 sieve. The AOS should be no larger than the openings in the U.S. Standard Sieve #70, and no smaller than the openings in the U.S. Standard Sieve #100 for proper soil retention.

For added clogging protection, the POA should be 4% or greater.

For permeability, k of the geotextile > k (soil).

(3) Soils with 15 to 50% finer than the #200 sieve. The AOS of the geotextile should be less than or equal to 1.0 times the d_{85} of the base soil. The POA should be 4% or greater.

For permeability, k of the geotextile > 10k (soil).

(4) Soils with less than 15% finer than the #200 sieve. The AOS of the geotextile should be less than or equal to 2.0 times the d85 of the base soil. The POA should be 6% or greater. The POA should be as large as possible and may range up to 30% for available geotextiles that meet the above criteria for this category of base soils.

For permeability, k of the geotextile > 10k (soil).

(5) In general, to reduce the possibility of clogging, the geotextile should not be specified with an AOS smaller than the U.S. Standard Sieve #100. If the criteria in 2, 3, or 4 above results in an AOS smaller than the #100 sieve, laboratory tests will be necessary for evaluating the clogging potential for a specific base soil and geotextile combination.

The AOS for each category should be as large as possible without exceeding the criteria listed.

b. Nonwoven Geotextiles. AOS is not a controlled property with nonwoven geotextiles. These geotextiles have a wide range of size openings.

(1) The maximum size opening should be no larger than a U.S. Standard Sieve #40. (As determined by methods in ASTM-D4751.)

(2) In general, nonwoven geotextiles retain more soil fines than do woven geotextiles. The structure of the mechanically bonded needle-punched fabric helps to decrease the internal fabric clogging potential.

(3) The nonwoven geotextiles have very good permeability characteristics and should be strongly considered where seepage flows are a concern.

(4) Nonwoven fabrics have a rougher surface than wovens. Therefore, the bond between the soil and the fabrics offer more resistance to sliding along the plane of contact.

c. Ultra Violet Light Protection. If the geotextile will be subjected to any long periods of exposure, a more severe test for ultra violent light should be specified in Section 7. The specified value of 150 hours (Table 1 or 2) is adequate for normal construction installation where the geotextile will be covered as specified. A test period of 500 hours should be specified where significant longer duration exposure is anticipated.

5. CONSTRUCTION CONSIDERATIONS.

a. Satisfactory performance of the selected geotextile is greatly dependent on the installation procedures and field preparation of the surface to be protected. When geotextile fabrics are used adjacent to fill or backfill, the fill soil placement is critical in preventing conditions subject to plugging of the fabric. The following techniques help minimize the movement of soils particles toward the fabric surface and provide more area for flow through the fabric.

(1) Prepare soil surfaces adjacent to fabrics so that all flow channels or voids larger than the openings in the fabric are eliminated.

(2) Utilize soil compaction and placement techniques to ensure that intimate contact between the fabric and the soil is maintained.

(3) Provide a surface area as large as possible for the filter (i.e., it is better to place the geotextile around the periphery of the drain trench with gravel and pipe inside than to place the fabric around the pipe where the surface area is smallest).

b. Other construction considerations specific to the function or type of application are:

(1) Slope Protection - Class I and II (as indicated in Tables 1 and 2, Material Specification 592).

(a) The method of placement of rock or other material on the geotextile may have to be specified. Placement should be accomplished by equipment capable of controlling the drop. Pushing or rolling rock over the geotextile should not be allowed. The maximum drop is 3 feet for protected or unprotected geotextile. Where conditions require a larger drop, the strength of the geotextile and/or thickness of cushioning materials need to be increased.

Class I - Unprotected - limit the height for dropping stone onto bare geotextile to 3 feet.

Class II - Protected - require the use of 6 inch sand or soil cushion for bedding the stone on the geotextile, and limit the height of drop to 3 feet.

(b) To prevent movement of surface soil where groundwater and seepage pressures are a factor, the geotextile must be in intimate contact with the soil. This is especially true on sloping surfaces where flow may occur beneath the fabric. A sand layer bedding material may have to be specified to insure this contact in some cases. Gravel placed on the geotextile will hold it in place and minimize voids under the riprap. Careful grading of this gravel placed over the geotextile is not important and pit-run gravel is often adequate if it is free draining. Embedment of the geotextile in a trench to form a cutoff at regular intervals down the slope will also help prevent rilling beneath the fabric. Cutoffs are to be more closely spaced in highly erodible soils and spaced wider apart in more stable soils.

(c) When a geotextile is used as a filter material replacement for the purpose of preventing particle migration, it is recommended that laps of adjacent fabric require machine sewing or other positive joining method. The method of overlap should be specified on the drawings or in the construction details.

(2) Subsurface Drainage - Class III (as indicated in Tables 1 and 2, Material Specification 592).

(a) Tables 1 & 2 are intended for normal operating conditions where material will not be dropped more

than five (5) feet onto the geotextile, where trench depths from the normal ground surface will be no deeper than ten (10) feet and sharp, angular aggregates are not used.

(b) The materials listed in Tables 1 & 2 are for average conditions. When the materials are used in trenches deeper than ten (10) feet or with sharp, angular aggregates, heavier geotextiles are recommended; tensile strength should be increased to 150 lbs. minimum, burst strength should be increased to 300 psi minimum.

(c) To prevent movement of surface soil where groundwater and seepage pressures are a factor, the geotextile must be in intimate contact with the subgrade soil. Voids between the geotextiles and the base soil need to be minimized to prevent the collecting of fines behind the fabric and subsequent clogging. The geotextile should be pulled flat during installation to eliminate wrinkles and folds that create voids.

(d) If flow in the plane of the geotextile is a concern in the drain installation, the type and thickness of the fabric becomes an important criterion. A heavier weight nonwoven needle punched fabric should be used.

(3) Road Stabilization - Class IV (as indicated in Tables 1 and 2, Material Specification 592).

(a) Tables 1 and 2 are intended for light to medium loading in both weight and frequency of traffic.

(b) If the subgrade is soft and it is determined in design that the potential for rutting is high, the minimum overlap should be increased to the following:

Recommended Geotextile Overlap

Blow Count (N)	Overlap (inches)
≥ 10	24
4 - 9	36
< 4	48

6. GENERAL DISCUSSION OF TABLES 1 and 2.

a. The materials covered under Table 1 are woven monofilaments that are generally black in color and don't change noticeably from one class to the next. Heavier monofilaments will produce stronger fabric, but if the AOS and POA also change, a heavier fabric could have the same strength as a lighter fabric. In woven geotextiles the AOS and POA must be considered along with the fabric mass per unit area, thus making field classification difficult.

b. The nonwoven materials covered under Table 2 are restricted to needle punched geotextiles with the exception of Class IV. These needle punched fabrics can generally be recognized in the field by weight. The Class I geotextiles are approximate 8 oz./yd^2; Class II, 6 oz./yd^2, and Class III, 5 oz./yd^2. Class IV allows the use of heat bonded geotextiles that are generally not previously needle punched. These materials weigh about the same as the Class III needle punched.

c. A class of geotextile should be selected based on the intended use with appropriate considerations for construction and installation methods. For the most part, once a class of geotextiles is selected, it is intended that materials from either Table 1 or 2 may be used. Where specific desired characteristics are provided by one type of geotextile vs. the other, the appropriate class and type may be specified.

GEOTEXTILE REFERENCES:

1. Specifiers Guide (Annual Issue), Geotechnical Fabrics Report, Industrial Fabrics Association International, 345 Cedar Bldg., Suite 450, St. Paul, MN 55101.

2. Geotextile Engineering Manual, Federal Highway Administration Geotechnical and Material Branch, HHO-33, Room 3203, 400 7th Street S.W., Washington, D.C. 20590.

3. Construction Fabric General Specifications Guidelines, Task Force 25, ASSHTO-AGC-ARTBA Joint Committee.

4. Koerner, Robert M. (1986), Designing with Geosynthetics, Prentice-Hall, Englewood Cliffs, NJ.

5. Design and Practice Manual, (1987) Polyfelt Inc., Technical Department, P.O. Box 727, Evergreen, AL 36401

TABLE 1. REQUIREMENTS FOR WOVEN GEOTEXTILES

Property	Test Method	Class I	Class II & III	Class IV
Tensile Strength (pounds) 1/	ASTM D 4632 Grab Test	200 min. in any principal direction	120 min. in any principal direction	180 min. in any principal direction
Bursting Strength (psi) 1/	ASTM D 3786 Diaphragm tester	400 min.	300 min.	NA
Elongation at Failure (percent) 1/	ASTM D 4632 Grab Test	<50	<50	<50
Puncture (pounds) 1/	ASTM D 4833	90 min.	60 min.	60 min.
Ultraviolet Light (percent residual tensile strength)	ASTM D 4355 150 hours exposure	70 min.	70 min.	70 min.
Apparent Opening Size - AOS	ASTM D 4751	As specified or a min. # 100 2/	As specified or a min. # 100 2/	As specified or a min. # 100 2/
Percent Open Area (percent)	CWO-02215-86	4.0 min.	4.0 min.	1.0 min
Permittivity (1/seconds)	ASTM D 4491	0.10 min.	0.10 min.	0.10 min.

1/ Minimum average roll value (weakest principal direction).

2/ U.S. standard sieve size.

TABLE 2. REQUIREMENTS FOR NONWOVEN GEOTEXTILES

Property	Test Method	Class I	Class II	Class III	Class IV 3/
Tensile Strength (pounds) 1/	ASTM D 4632 Grab Test	180 min.	120 min.	90 min.	115 min.
Bursting Strength (psi) 1/	ASTM D 3786 Diaphragm tester	320 min.	210 min.	180 min.	NA
Elongation at Failure (percent) 1/	ASTM D 4632 Grab Test	>50	>50	>50	>50
Puncture (pounds) 1/	ASTM D 4833	80 min.	60 min.	40 min.	40 min.
Ultraviolet Light (percent residual tensile strength)	ASTM D 4355 150 hours exposure	70 min.	70 min.	70 min.	70 min.
Apparent Opening Size - AOS	ASTM D 4751	As specified, max. # 40 2/	As specified, max. # 40 2/	As specified max. # 40 2/	As Specified, max. # 40 2/
Permittivity (1/seconds)	ASTM D 4491	0.70 min.	0.70 min.	0.70 min.	0.10 min.

1/ Minimum average roll value (weakest principal direction).

2/ U.S. standard sieve size.

3/ Heat-bonded or resin bonded geotextile may be used for Class IV only, and are particularly well suited for this use. Needle punched geotextiles are required for all other classes.

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