# GUIDE FOR THE USE OF WISCONSIN CONSTRUCTION SPECIFICATION 13

# GEOTEXTILES

## 1. Introduction

Geotextiles 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 geotextile use is appropriate and the type that should be used. Properties that must be determined include strength, apparent opening size (AOS) for filtering, net open area, 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. It is important to verify the physical properties of the specified geotextile using one of the methods prescribed in the National Engineering Manual, Sections 512.20 and 512.21.

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

### A. Drainage

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

### B. Filtration

This is the ability of a geotextile to allow fluid flow through 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

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

### D. Separation

This is the ability of a geotextile to keep two different materials apart during installation and subsequent use that would otherwise tend to allow the materials 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 BY USE and TABLE 2, REQUIREMENTS FOR NONWOVEN GEOTEXTILES BY USE.

A. Slope Protection

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 include 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.

WOVEN FABRICS SHALL NOT BE USED ON SLOPES STEEPER THAN 2:1.

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. Cattle and/or equipment crossings in waterways and/or streams are examples of this application.

3. 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 prevention of clogging. Woven geotextiles require more critical evaluation and analysis than nonwovens in most applications. The following guidelines are recommended for determining requirements for the geotextile to be used.

A. Woven Geotextiles

The apparent opening size (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 that could affect the underlying base soil. The AOS test provides a means of evaluating the retention characteristics of a geotextile while percent open area (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 does not provide a direct measure of field performance.

The guidelines listed below are based on NRCS Design Note No. 24, Guide for the Use of Geotextiles (November 1991). The base soil gradation must be known. If the base soil has particles larger than the #4 sieve, the gradation of the base soil must first be regraded after removing all material larger than the #4 sieve. 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 unless a layer of sand is used between the base soil and the geotextile. The AOS of the geotextile is then determined using the sand as the base soil.

2) Soils with 51% to 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 #100 sieve for proper soil retention. The POA should be 4% or greater for added clogging protection.

3) Soils with 15% to 50% finer than the #200 sieve.

   The AOS of the geotextile should be less than or equal to the D85 of the base soil. The POA should be 4% or greater.

4) Soils with less than 15% finer than the #200 sieve.

   The AOS of the geotextile should be less than or equal to 2 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.

In general, to reduce the possibility of clogging, the geotextile should not be specified with an AOS smaller than the #100 sieve. If the previously stated criteria results in an AOS smaller than the #100 sieve, laboratory tests will be required 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 controlling property with nonwoven geotextiles. These geotextiles have a wide range of size openings.

1) The maximum size opening should be no larger than the #40 sieve.

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 violet light should be specified. The specified value of 150 hours (Table 1 or 2) is adequate for normal construction installation and coverage. A test period of 500 hours should be specified where a significantly longer duration of exposure is anticipated.

4. 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 that promote the plugging of the fabric. The following techniques help minimize the movement of soil particles toward the fabric surface and provide more area for flow through the fabric.

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

2) Use soil compaction and placement techniques that ensure intimate contact between the fabric and the soil.

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 a 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 Table 1 or Table 2).

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 placing the material without damaging the geotextile or separating any joints or overlaps. Pushing or rolling rock over the geotextile shall not be allowed.

CLASS I (UNPROTECTED) - in general, the height limit for dropping stone onto bare geotextile is 3 feet. If conditions require a larger drop or the rock has sharp angular surfaces, consider placing a 6 inch sand or soil cushion on the geotextile or increasing the required tensile and bursting strengths. Increase the minimum nonwoven geotextile tensile strength to 250 psi and the bursting strength to 400 psi. Increase the minimum woven geotextile tensile strength to 300 psi and the busting strength to 500 psi.

CLASS II (PROTECTED) - requires the use of a 6-inch sand or soil cushion for bedding the stone on the geotextile.

b) To prevent movement of surface soil where groundwater and seepage pressures are a factor, the geotextile must be in intimate contact with the base soil. This is especially true on sloping surfaces where flow may occur beneath the fabric. A sand bedding layer 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 rock. Careful grading of this gravel placed over the geotextile is not important. Pit-run gravel is 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 may have to be as close as 10 feet apart (vertically) in highly erodible soils and spaced up to 20 feet apart (vertically) in more stable soils.

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

2) Subsurface Drainage - CLASS III (as indicated in Table 2).

a) Table 2 is intended for normal operating conditions where material will not be dropped more than 5 feet onto the geotextile, where trench depths from the normal ground surface will be no deeper than 10 feet, and sharp, angular aggregates are not used.

b) When trench depths are greater than 10 feet or sharp, angular aggregates are used, heavier geotextiles are recommended. The tensile strength should be increased to

150 pounds minimum, and the bursting 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 geotextile 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 if flow within the geotextile plane is expected.

3) Road Stabilization - CLASS IV (as indicated in Table 1 or Table 2).

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 of 24 inches shall be increased to 36 inches.

**Table 1. Requirements for Woven Geotextiles by Use**

| Property | Test Method | Slope Protection | | Road Stabilization | |
|---|---|---|---|---|---|
| | | Unprotected (Class I) | Protected (Class II) | (Class IV) | Slit Tape |
| Tensile Strength (lbs.)[1] | ASTM D 4632 Grab Test | ≥250 in any principal direction | ≥120 in any principal direction | ≥180 in any principal direction | ≥200 in any principal direction |
| Elongation at failure (Percent)[1] | ASTM D 4632 Grab Test | ≤20 | ≤35 | ≤35 | ≤10 |
| Puncture (lbs.)[1] | ASTM D 6241 | ≥900 | ≥350 | ≥350 | ≥700 |
| 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 | ≥ #100 (.150 mm) and ≤ #70 (.212 mm)[3] | ≥ #100 (.150 mm) and ≤ #70 (.212 mm)[3] | ≥ #100 (.150 mm) and ≤ #70 (.212 mm)[3] | As specified or a min. size > #50[3] |
| Percent Open Area (POA) | CW-02215[2] | 4.0 min. | 4.0 min. | 1.0 min. | N/A |
| Permittivity (1/seconds) | ASTM D 4491 | 0.20 min. | 0.10 min. | 0.10 min. | 0.05 min. |
| (gal/sq. ft./min.) | | 15 min. | 7.5 min. | 7.5 min. | 3.8 min. |

[1]Minimum average roll values (MARV); calculated as the mean minus two standard deviations, yielding a 95 percent confidence level that the table value will be equaled or exceeded.

[2]Test Methods prepared by U. S. Army Corps of Engineers

[3]U. S. Standard Sieve Size

**Table 2. Requirements for Nonwoven Geotextiles by Use**

| Property | Test Method | Slope Protection | | Subsurface Drainage | Road Stabilization |
|---|---|---|---|---|---|
| | | Unprotected (Class I) | Protected (Class II) | (Class III) | (Class IV)[3] |
| Tensile Strength (lbs.) [1] | ASTM D 4632 Grab Test | ≥180 | ≥120 | ≥90 | ≥180 |
| Elongation At failure(percent)[1] | ASTM D 4632 Grab Test | ≥ 50 | ≥ 50 | ≥ 50 | ≥ 50 |
| Puncture(lbs.) [1] | ASTM D 6241 | ≥350 | ≥250 | ≥200 | ≥200 |
| Ultra- Violet 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 or max. #40 (.425 mm) [2] | As specified or max. #40 (.425 mm) [2] | As specified or max. #40 (.425 mm) [2] | As specified or max. #40 (.425 mm) [2] |
| Permittivity (1/seconds) (gal/sq. ft./min.) | ASTM D 4491 | 0.70 min.<br>52.5 min. | 0.70 min.<br>52.5 min. | 0.70 min.<br>52.5 min. | 0.10 min.<br>7.5 min. |

[1]Minimum average roll values (MARV); calculated as the mean minus two standard deviations, yielding a 95 percent confidence level that the table value will be equaled or exceeded.

[2]U. S. Standard Sieve Size.

[3]Heat-bonded or resin-bonded geotextile may be used.

## Examples for the Use of the Guide and Construction Specification 13

Example 1 - Slope Protection Using a Woven Geotextile.

a. Soil data indicates that 70% is finer than the #200 sieve and 100% is finer than the #4 sieve.

b. The rock for riprap is slightly rounded and will not be dropped from a height which exceeds 3 feet.

The geotextile requirements will be in accordance with Table 1, Class I if the rock will be placed on bare geotextile or Class II if a sand layer over the geotextile will be used.

Part 2. A. requires that the slope on which the geotextile will be placed shall be 2:1 or flatter.

Part 3. A. provides required information on the geotextile size openings.

1) The POA must be 4% or greater.

2) The AOS must be between the #70 and #100 sieve size openings (inclusive). (This information is shown in Specification 13.) The #100 sieve information must also be specified by the designer.

Part 4. B. 1) a) states that the protected class requires the use of a 6-inch sand or soil cushion over the geotextile. This requirement must be shown or stated in the construction plans.

If the installation would require dropping the rock from a height greater than 3 feet onto the bare geotextile or if the rock has sharp surfaces, follow the guidelines in Part 4. B. 1) a) for Class I.

Example 2 - Slope Protection Using a Nonwoven Geotextile.

a. Soil data indicates that 70% is finer than #200 sieve and bank seepage is present.

b. The rock for riprap will probably be dropped from a height which exceeds 3 feet.

Refer to Parts 3. B. and 4. B. and Table 2.

The most important item is that the AOS shall be no larger than the openings in a #40 sieve. Sieves with numbers larger than 40 have smaller openings and will meet this requirement.

All criteria for the geotextile are listed in Table 2, under Slope Protection, Unprotected (Class I). This information assumes a dropping height of 3 feet for the rock. Since this is not the case, refer to Part 4. B. 1) a) for additional recommendations.

The larger drop height can be accommodated by doing one or both of the following:

1) Place a 6 inch layer of sand on the geotextile prior to placing the rock.

   This information must be placed in the construction plans.

2) Increase the tensile and bursting strengths. Suggested strengths are 250 psi for tensile and 400 psi for bursting.

   This information must be placed in Table 2 of Specification 13 by a pen-and-ink change.