EB533 GEOTEXTILES IN FILTRATION AND DRAINAGE

BACKGROUND

The purpose of filter geotextiles is to permit the free flow of water while retaining soil particles behind the fabric and preventing contamination of the drainage media. Some applications of this function include french drains, highway edge drains, retaining wall drainage systems, and landfill leachate collection systems. The ability of a geotextile to allow sufficient water flow, while retaining the soil being drained is a critical design requirement for these applications. This Engineering Bulletin introduces important concepts in measuring flow through soil/geotextile systems and evaluating geotextile openings and, provides practical recommendations for specifying filter geotextiles.

The geotextile and adjacent soil filter zone together control ultimate flow capacity of the system. The geotextile plays a significant role in developing a filter zone in the soil that most significantly controls water flow. Development of a soil filter zone is illustrated in Figure 1. Figure 1 (a) shows a soil/geotextile filter system immediately after construction. Smaller particles directly adjacent to the geotextile should pass through the fabric. Larger particles will be retained and will in turn retain finer particles in the soil thus forming a filter within the soil, as shown in Figure 1 (b). Filter system flow capacity or flow rate, q, is the quantity of water that will pass through a unit of area in a given period of time. Flow capacity is usually expressed in gallons/min/sq. ft (liters/min/sq. m).

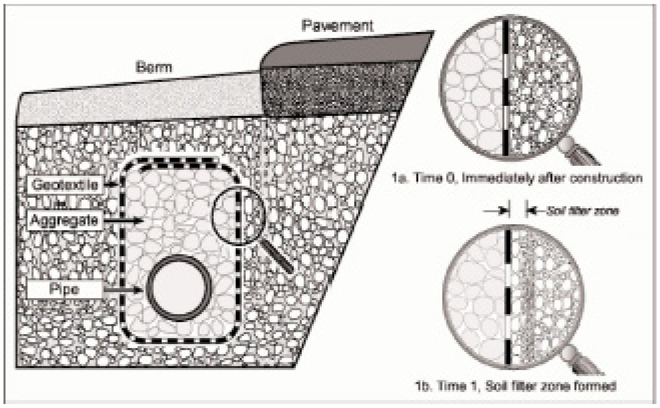

Figure 1 - Example of Highway Edge Drain

SOIL PERMEABILITY

Soil permeability, ks, is a hydraulic characteristic of soil that can be measured in the laboratory. It is a measure of the ease with which water can flow through the soil. Velocity units are used for permeability, typically cm/sec. Once this property is known, the soil flow capacity can be calculated for any given condition of hydraulic gradient and flow area using Darcy's law.

GEOTEXTILE PERMITTIVITY

Permittivity is a laboratory-measured characteristic of the geotextile, expressing the flow capacity of the geotextile per unit of head. American Society for Testing and Materials (ASTM) D-4491, "Standard Test Methods for Water Permeability of Geotextiles by Permittivity" is the industry standard method for measuring geotextile permittivity. This is an index test and measures water flow rate through a geotextile in an isolated condition. Consequently, it does not provide any information about flow capacity of a soil/geotextile system. Once permittivity is known, the flow capacity of the geotextile can be calculated for any given combination of hydraulic gradient and flow area. Permittivity is expressed in units of reciprocal time (sec-1) and is derived from Darcy's law as follows:

$$q = k_g i_g$$

$$q = \frac{k_g \Delta h_g}{t}$$

$$q = \Psi \Delta h_g$$

$$\Psi = \frac{k_g}{t}$$

Where:

k = geotextile coefficient of permeability

i = hydraulic gradient across the geotextile,(Δh_g)/t

Δh = change in hydraulic head or head loss across the geotextile

t = geotextile thickness

Ψ= geotextile permeability

As shown by these equations, two characteristics impact geotextile flow capacity: geotextile permeability and

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thickness. Geotextile permittivity expresses these two characteristics in one variable.

Permittivity should be used to specify geotextiles. Specifying geotextile permeability may not provide for adequate water flow. Two geotextiles that have the same permeability may not have the same flow capacity. From the previous equations it can be observed that if one geotextile of these two geotextiles is half the thickness of the other one, the flow through the thinner geotextile will be twice as much since the flow rate is inversely proportional to the thickness. This example demonstrates that geotextile permeability does not correlate directly to water flow. Conversely, geotextiles with equivalent permittivity will have the same flow capacity. By specifying geotextile permittivity, the design engineer is assured that the geotextile product submitted will meet the required index geotextile flow capacity. The nationally recognized American Association of State

Highway and Transportation Officials (AASHTO) M 288 specification for geotextiles in highway applications uses permittivity to distinguish geotextiles for varying applications and conditions.

APPARENT OPENING SIZE (AOS)

In addition to sufficient permittivity, the openings in the geotextile need to be large enough to allow some soil to pass through the geotextile to develop the soil filter zone shown in Figure 1 (b), and small enough to prevent too much loss of soil. ASTM D-4751, "Standard Test Method for Determining Apparent Opening Size of a Geotextile" approximately measures the largest particle that can pass through the geotextile. AOS is typically specified as a US Standard Sieve size or as the sieve opening size in millimeters. Sieve sizes are given in openings per inch, thus, as the sieve number increases the opening becomes smaller. Selection of an AOS should be based on the gradation of the soil being retained by the geotextile. For design guidance, the AASHTO specifications use the amount of soil passing the #200 sieve. Specifications should identify the maximum allowable AOS, which is expressed as the smallest allowable sieve size, which is the maximum opening size. In most cases, proper selection of the geotextile AOS will eliminate clogging or piping potential.

SPECIFICATIONS FOR GEOTEXTILE PERMITTIVITY AND AOS

The recommended permittivity values shown in Table 1 come from the AASHTO M 288 specification. These are default or guideline values and may be modified based on results of site specific hydraulic testing. AASHTO divides filtration geotextiles into subsurface drainage and permanent erosion control. Subsurface drainage includes trench and blanket type drains.

Permanent erosion control is principally geotextiles used under rock riprap. The geotextile properties are specified according to the amount of material passing the Number 200 sieve in the soil being retained by the geotextile. In general the higher the fines content the lower the permittivity requirement and the tighter the AOS specified.

AASHTO also has specifications for geotextiles used under roads and in silt fences.

- For separation (geotextile is used to separate dissimilar materials where subgrade soils are > 3 CBR and water seepage through the geotextile is not a critical function) the default permittivity value is 0.02 sec-1 but the permittivity of the geotextile should be greater than that of the soil. The maximum AOS value should be 0.60 mm or #30 sieve.
- For stabilization (geotextile is used to separate and filter over wet subgrade soils down to 1 CBR) the default permittivity value is 0.05 sec-1 but the permittivity of the geotextile should be greater than that of the soil. The maximum AOS should be 0.43 mm or a #40 sieve.
- For silt fences (geotextile is used as a vertical, permeable interceptor to remove suspended soil from overland water flow) a default permittivity value of 0.05 sec-1 is recommended. A maximum AOS of 0.60 mm or #30 sieve is specified for silt fence applications.

CRITICAL APPLICATIONS

The criteria given previously are for the most common applications and conditions where the drainage system is not critical. For critical designs or where problem soils (such as gap-graded soils) are anticipated, filter design requires determination of the site specific soil/geotextile system performance. The only way to determine system permeability is to perform laboratory testing which simulates field conditions. There are two test methods available to evaluate flow capacity of a site specific soil/ geotextile system. Both methods evaluate the filtration properties of a specific geotextile with a site specific soil. The two methods are ASTM D-5101, "Standard Test Method for Measuring the Filtration Compatibility of Soil-Geotextile Systems" known as the gradient ratio test and ASTM D-5567, "Standard Test Method for Hydraulic Conductivity Ratio (HCR) Testing of Soil/Geotextile Systems" known as the HCR test. The gradient ratio test is generally more applicable where the geotextile will be used to filter high permeability or loose soils. The HCR test is more appropriate for applications in which the geotextile will filter soils with a permeability of less than about 0.01 cm/sec or tighter soils.

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References

1. ASTM, 2014, "ASTM D-4491-14, Standard Test Methods for Water Permeability of Geotextiles by Permittivity," American Society for Testing and Materials, West Conshohocken, PA.

2. ASTM, 2012, "ASTM D-4751-12, Standard Test Method for Determining Apparent Opening Size of a Geotextile," American Society for Testing and Materials, West Conshohocken, PA.

3. AASHTO, "Standard Specification for Geotextile Specification for Highway Applications, AASHTO Designation: M 288-05", American Association of State Highway and Transportation Officials, Washington, D.C., 2005.

4. ASTM, 2012, "ASTM D-5101-12, Standard Test Method for Measuring the Filtration Compatibility of Soil-Geotextile Systems," American Society for Testing and Materials, West Conshohocken, PA.

5. ASTM, 2011, "ASTM D-5567-11, Standard Test Method for Hydraulic Conductivity Ratio (HCR) Testing of Soil/Geotextile Systems," American Society for Testing and Materials, West Conshohocken, PA.