FINAL REPORT

DEVELOPING VTM-51 INTO AN ASTM TEST METHOD

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VDOT
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VIRGINIA TRANSPORTATION RESEARCH COUNCIL

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/VA-94-R2		

4. Title and Subtitle	5. Report Date
Developing VTM-51 into an ASTM Test Method	September 1993
	6. Performing Organization Code HPR #45
7. Author(s) David C. Wyant	8. Performing Organization Report No. VTRC 94-R2
9. Performing Organization Name and Address Virginia Transportation Research Council Box 3817, University Station Charlottesville, Virginia 22903-0817	10. Work Unit No. (TRAIS) HPR #45 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Virginia Department of Transportation 1401 E. Broad Street Richmond, Virginia 23219	13. Type of Report and Period Covered Summary Report 14. Sponsoring Agency Code

15. Supplementary Notes

In cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. Abstract

In 1980, the Virginia Transportation Research Council developed a procedure to test silt fence installations (VTM-51). The test determines the filtering efficiency (amount of soil removed) and the flow rate of a geotextile. A known concentration and volume of sediment-laden water is timed as it passes through a geotextile sample.

In 1988, ASTM Committee D35 requested that the Virginia Transportation Research Council consider developing VTM-51 into an ASTM Test Method. This report documents the many tests performed to meet this request, the numerous reviews of ASTM committees and subcommittees, and other work efforts required to develop ASTM Test Method 5141, Determine Filtering Efficiency and Flow Rate of a Geotextile for Silt Fence Application Using Site Specific Soil. The major differences between the two test methods are the number of samples to be tested, the number of runs on each sample, and the soil used.

17. Key Words	18. Distribution Statement
silt fence, filtration, flow rate, erosion control, geotextile	No restrictions. This document is available to the public through NTIS, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	24	

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(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

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Charlottesville, Virginia

September 1993
VTRC 94-R2

ENVIRONMENTAL RESEARCH ADVISORY COMMITTEE

ABSTRACT

In 1980, the Virginia Transportation Research Council developed a procedure to test silt fence installations (VTM-51). The test determines the filtering efficiency (amount of soil removed) and the flow rate of a geotextile. A known concentration and volume of sediment-laden water is timed as it passes through a geotextile sample.

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INTRODUCTION

In the mid 1970s, the Virginia Department of Transportation (VDOT) started using geosynthetics in lieu of straw bales as temporary erosion control measures. However, VDOT personnel (in particular, field forces) had doubts about their effectiveness. As a result of these doubts, the Department requested the Research Council's assistance in ascertaining the effectiveness of the different geosynthetics being presented to and used by the Department. As a result, this study was initiated to determine the properties and the suitability of geosynthetics for use as silt fence material.[1]

In the 1970s, there were no test methods for civil engineering applications of geosynthetics, since they were new to that discipline. One of the many test methods developed during this study modeled a silt fence installation. This test was developed to determine the effectiveness of geosynthetics to filter soil out of the runoff water while allowing the water to pass through the geosynthetic.[2] This test method was modeled after a similar test method used by the Research Council in the early 1970s to evaluate the effectiveness of various hay and straw bales.[3]

After many tests with different geosynthetics and three soils, it was accepted by VDOT as a performance test method to determine whether a geosynthetic met VDOT's silt fence specifications for filtration efficiency and flow rate.[4] As a result, this test method became an approved VDOT test method: Virginia Test Method #51 (VTM 51).[5]

As geosynthetics were becoming a major part of civil engineering projects nationwide, there was a need for industry-wide test methods to determine their in-situ performance. The American Society of Testing and Materials (ASTM) was involved in the development of geosynthetic test methods, practices, and standards. Since the author had developed one of the few filtration tests for geosynthetics, ASTM Committee D35 on Geosynthetics asked the author in 1988 to modify VTM-51 to make it an ASTM test method.

This report documents the tests performed to meet this request, the ASTM review process, and the work effort as outlined in the 1988 work plan.[6] In late 1991, a modified VTM-51 was finally approved as ASTM Test Method D5141, Determining Filtration Efficiency and Flow Rate of a Geotextile for a Silt Fence or Silt Barrier Application.[7] After the test method's approval in 1991, ongoing round robin testing was initiated.

PURPOSE AND SCOPE

This study was undertaken to develop VTM-51 into an ASTM test method. Since VTM-51 is a test method designed for Virginia's weather and soil conditions, it needed to be altered to make it applicable for other conditions that may be encountered in other states and even in other parts of the world.

APPROACH

The VTM-51 Test Method, described in Appendix A, is a model of a silt fence installed in a drainage ditch to retard the flow of the runoff and retain the soil being carried in the runoff. The test method models a silt fence in a ditch with an 8 percent slope and a silty soil during three storms with 1 inch of rain each. Sediment-laden water is placed behind the silt fence material, and the amount of soil removed by passage of the water through the geotextile is determined.

After some initial testing in several laboratories throughout the U.S., a monofilament geotextile, which was felt by different producers to be the most commonly made material, was chosen as the geotextile to use in this study. After ascertaining the test method's variability, the factors in the following list were varied one at a time to determine the effect on the filtering efficiency and flow rate:

- The sediment-laden water was introduced behind the geotextile from a vertical container rather than dumping the water over the side of the flume from a large trash can.
- The volume of the sediment-laden water was reduced to half that of the first group of tests, but the suspended solids concentration was kept the same (3,000 parts per million [ppm]).

- The concentration of suspended solids was reduced to half (3,000 ppm to 1,500 ppm) of that in the first group of tests.
- The sample width was reduced from 32 inches in VTM-51 to 16 inches.
- The slope was increased from 8 percent to 12 percent.
- The direction the sample was cut from the roll was changed 90 degrees.

FINDINGS

Ballot Development

The author performed many tests and made many contacts with ASTM members during each phase of ballot development of the test method for ASTM. A phase is defined in this study as 6 months, since ASTM meets twice a year. A brief outline of the long process required by ASTM is shown. The lines indicate approximately 6 months (or one phase).

- Task Force formed.
- VTM-51 reviewed by Task Force and background testing requested.

- Background testing results reviewed by Task Force and additional testing requested.

- VTM-51 rewritten in ASTM ballot format.
- ASTM ballot reviewed by D35 Editorial Committee.
- Ballot finalized for D35 Subcommittee (S/C) review.
- Ballot reviewed by S/C.
- Negatives on S/C ballot addressed.

- Additional testing performed to answer some of the S/C concerns.
- Negative S/C ballots resolved.

- Next draft of the ballot finalized.
- Draft reviewed by Main Committee D35 (M/C).
- Negatives on the Main Committee (D35) ballot were addressed the same way as the S/C negatives.

- After the D35 ballot negatives were resolved, the ballot was again drafted to reflect the resolved negatives.
- Ballot reviewed by ASTM Society.
- Negatives were addressed as with earlier ballots.

- The final draft of the ballot was submitted to ASTM as a test method ready for publication.

Over the past several years, there were several occasions that required a draft to be reballoted a second time at a particular level (S/C, M/C, or Society) because of significant changes in the document. All in all, the balloting process for this test method took approximately 6 years.

Laboratory Testing Results

After some initial testing in several laboratories throughout the U.S., it was decided to limit the testing to one laboratory (Research Council), one operator, one soil (a silty soil), and a monofilament geotextile. Initially, it was decided to follow VTM-51 and to determine the sensitivity of the test method to changes of one parameter. VTM-51 states that the flume be on an 8 percent slope and that 3,000 ppm sediment-laden water made from the silty soil be placed over the side of the flume to simulate the runoff water in a drainage ditch. This procedure is repeated three times (to simulate three storms) for each sample of the geotextile (Appendix A). Table 1 indicates the variability of filtration efficiency and flow rate for a large number of samples run according to VTM-51.In the VTM-51 procedure, the elapsed time from the moment the sediment-laden

Table 1
VARIABILITY OF FILTERING EFFIEINCY AND FLOW RATE

	Average	Standard Deviation
Filtering Efficiency (%)	91	0.9
Flow Rate (gal/sq ft/min)	0.34	0.07

water is dumped in the flume until it drains down to a mark 10.5 inches from the sample is determined. This time is used to calculate the flow rate for that test. Concern was raised by the Task Force that with some geotextiles, the time to drain to this mark was excessive and not an accurate assessment of the geotextiles' performance in the field. Because of this concern, the author calculated the settling rate of the soil particles in the silty soil being used in VTM-51. After some discussion, it was decided to investigate several other alternatives in timing the flow rate for each test (see Table 2). In addition to the 10.5-inch timing mark, two other timing marks 20 and 13 inches behind the geotextile were placed in the flume. As a fourth alternative, the distance of the water behind the geotextile 25 minutes after the test commenced was selected. The flow rate could then be calculated from this distance. Twenty-five minutes was chosen because that is the time it takes runoff to fill up a silt fence during a normal rain. In addition, most soil removed from runoff water behind a silt fence occurs by settling, and at 25 minutes of resident time behind a silt fence, the soil particles that are left in suspension will not settle out without some flocculent.[8] For VTM-51's standard soil, that means the filtering efficiency is 75 percent at the elapsed time of 25 minute's.

After reviewing these data, the Task Force decided that the test method should use the time for complete drainage (if less than 25 minutes) or 25 minutes, whichever occurs first.

Although the sediment-laden water is dumped over the side of the flume in VTM-51, it was felt that a better-controled means of releasing the water behind the geotextile sample was needed. Therefore, it was decided to use a large upright container at the upper end of the flume. Table 3 shows the data for both release methods.

Although the average values for both the filtration efficiency and flow rate are essentially the same for the end- and side-dump methods, the variability for

Table 2
FILTRATION EFFICIENCY AND FLOW RATE UNDER DIFFERENT CONDITIONS

	Distance (in)		Time (min)	
	10.5 in	13 in	20 in	25 min
Filtering Efficiency (%)				a
Average	91	91	90	
Std. Dev.	.9	.9	.8	
Flow Rate (gal/sq ft/min)				
Average	.34	.40	.60	.91
Std. Dev.	.07	.08	.10	.06

a. Filtering efficiency was not measured at the conclusion of each test, since it was determined to be 75 percent.

Table 3
DIFFERENT METHODS OF WATER RELEASE

	Filtration Efficiency 10.5 in		Flow Rate (gal/sq ft/min) 10.5 in.		10.5 in.	
	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.
Side Dump	91	.9	.34	.07	.91	.06
End Dump	92	2.6	.32	.19	.94	.06

both is higher at the 10.5-inch mark than would be desirable. However, the Task Force decided that the end dump method should be used for several reasons. The method of releasing the sediment-laden water at the end of the flume makes the test method easier to perform (the soil can be uniformly mixed better and the volume of water being released is very heavy and difficult to dump over the side of the flume). At 25 minutes, which is the maximum time of a test, the data for both methods are essentially the same. Also, it appeared that the variability was less as the test ran to completion.

In an attempt to expedite and make the test easier to perform, the volume of water was reduced by 50 percent but the total suspended solids were kept the same (3,000 ppm). Table 4 shows the data for the standard runs of 50 liters and for the reduced runs of 25 liters. It was decided to keep the volume of water at 50 liters.

Another suggested change in VTM-51 was in the total suspended solids (TSS) concentration being used. It was decided to see the effects of reducing the initial TSS from 3,000 ppm to 1,500 ppm even though 3,000 ppm is the normal concentration in a typical drainage ditch. Table 5 shows the results of tests run for the two concentrations.

Table 4
VOLUME OF WATER

	25 liters	50 liters
Filtering Efficiency (%)		
Average	93	91
Standard Deviation	1.3	.90
Flow Rate (gal/sq ft/min)		
Average	.22	.34
Standard Deviation	.08	.07

Table 5
EFFECTS OF INITIAL TOTAL SUSPENDED SOLIDS

	Total Suspended Solids	
	3,000 ppm	1,500 ppm
Filtering Efficiency (%)		
Average	91	94
Standard Deviation	0.9	1.3
Flow Rate (gal/sq ft/min)		
Average	.34	.22
Standard Deviation	.07	.08

After reviewing the results in Table 5 the Task Force decided to use 3,000 ppm to TSS since the results are more variable for the lower TSS, and 3,000 ppm is a better model of the field conditions.

It was suggested that a smaller flume be investigated so as to make the test easier to perform. A second flume half the width of the original flume in VTM-51 was built. Table 6 shows the results of tests performed with both flumes. The smaller flume produced results with less accuracy than the larger flume, thus the 32-inch wide flume is used in the ASTM test method.

Another suggestion was to vary the slope of the flume. Table 7 shows the results of tests run for two different slopes. The Task Force reviewed Table 7's data and expressed some concern about the low flow rate for the steeper slope. After some discussion the group decided it was best to continue to use the common slope of 8 percent.

Early in the development of the test method, concern was raised about the effects of the sampling process of the geotextile. At that time, the monofilament geotextile had not been selected as the sole product. The Task Force selected a woven geotextile, which is similar to the monofilament product, as the product to test. It was decided to test geotextile samples cut in the direction

Table 6
DIFFERENT FLUME WIDTHS

	Flume Width	
	16 inches	32 inches
Filtering Efficiency (%)		
Average	88	91
Standard Deviation	1.2	0.9

Table 7
EFFECT OF SLOPE ON VTM-51

	Slope (%)	
	8	12
Filtering Efficiency (%)		
Average	91	91
Standard Deviation	0.9	0.9
Flow Rate (gal/sq ft/min)		
Average	.34	.17
Standard Deviation	.07	.02

Table 8
EFFECT OF DIRECTION OF PRODUCTION
ON THE FILTERING EFFICIENCY AND FLOW RATE

Direction of Production	Filtering Efficiency (8%)	Flow Rate (gal/sq ft/min)
Machine	90	0.15
Cross-machine	92	0.14

of its production (machine direction) and compare them with the samples taken 90 degrees to the production (cross-machine direction). Table 8 has the results of the tests for three samples of the woven geotextile cut from both production directions.

After review of these data, the Task Force decided to keep the machine direction of sampling as the preferred direction. This decision was based on the above data and the fact that the machine direction is the direction of installation of a silt fence.

CONCLUSIONS

The following decisions were made from the testing conducted during the development of the test method.

1. The samples of geotextile would be cut from the machine direction.

2. The flume would be 32 inches wide and set at an 8 percent slope.

3. The sediment-laden water would be released behind the geotextile from a vertical container.

4. The total suspended solids would be 3,000 ppm in 50 liters of water.

5. The time for complete drainage (but no more than 25 minutes) will be used in the test method.

After considering the many different conditions encountered in other states as well as the way other states view their temporary siltation control measures, such as silt fences, the Task Force decided that VTM-51's procedures were only applicable for Virginia's situations. Therefore, the group decided that the test method should be written as a procedure to follow for a single test and not a group of runs as Virginia does. However, the test method does not exclude a state from running multiple tests on the same sample as Virginia specifies.

Another change in the Virginia test method is that the soil in the water should be site-specific and not the standard soil used by VDOT.

With these changes made by the D35 Task Force, ASTM D5141, Standard Test Method for Determining Filtering Efficiency and Flow Rate of a Geotextile for Silt Fence Application Using Site-Specific Soil, was developed and published in 1991 (Appendix B).

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3. Poche, D. J. and Sherwood, W. C. 1976. Sediment trapping efficiency of straw and hale bale barriers. Paper read at Transportation Research Board, January 1976. Washington, D.C.

4. Virginia Department of Transportation. 1991. Road and bridge specifications. Richmond, Virginia.

5. Virginia Department of Transportation. Virginia test methods manual. Richmond, Virginia.

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7. American Society of Testing and Materials. 1993. Annual book of ASTM standards. Volume 04.08. Philadelphia, PA.

8. Virginia Department of Highways and Transportation. Erosion and siltation control manual. Richmond, Virginia.

APPENDIX A

VTM-51 TEST METHOD

Virginia Test Method

For

Filtering Efficiency And Flow Rate Of A Filter Fabric

Designation: VTM-51

1. Scope

This method covers the procedure to be used in determining the filtering efficiency and flow rate of a commercial filter fabric.

2. Apparatus

a. A flume 48 inches long and 32 inches wide by 12 inches high with a gutter attached to one side. (See Figure 1).

b. Two 20 gallon containers.

c. A stirrer on a 1/4 inch portable drill.

d. Stopwatch.

e. A DH-48 integrated water sampler with 500 ml bottles.

3. Procedure

a. Stretch a sample of the fabric 39 inches long by 12 inches wide across the flume opening 32 inches wide and fasten securely in place to assure that all the sediment-laden water passes through the sample. Note: The flume opening is the standard length of a straw bale.

b. Elevate the flume to an 8 percent slope.

c. Take a depth integrated suspended solids sample from an untreated, fairly sediment free water supply. Continuously agitate the supply for uniformity during the sampling process.

d. Prewet the fabric by passing 50 liters of untreated, fairly sediment free water through it.

e. Mix 150 grams of minus 10 material of a silty soil (See Gradation Curve, Figure 2) in 50 liters of the untreated water placed in one of the 20 gallon containers. Thoroughly agitate the solution with the stirrer on the 1/4 inch portable drill to obtain a uniform mix.

f. After uniformly mixing the solution, quickly dump the solution behind the fabric sample in the flume. Start the timer at dumping.

g. Rinse the mixing container with 1 or 2 liters of the filtrate and dump into the flume.

h. Time the flow of water through the fabric until the water level drops to a point 10.5 inches behind the fabric. At this point the flow rate has essentially ceased.

i. Collect all filtrate in a second mixing container.

j. At the completion of the test, agitate the collected filtrate until the mixture is uniformly mixed. Obtain a depth integrated suspended solids sample from the mixture during agitation.

k. Process the two suspended solids samples by the "nonfilterable residue" procedure described in the 14th edition of Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, WPCH).

l. Calculate the flow rate of the fabric as follows:

Flow rate (gal./sq. ft./min.) = 14.85/time (min.)

m. Calculate the filtering efficiency (F.E.) of the fabric as follows:

$$F.\ E. = \frac{(S.S._{bg} + 3000) - S.S._{After}}{(S.S._{bg} + 3000)} \times 100,$$

where $S.S._{After}$ and $S.S._{bg}$ are the suspended solids value after filtration and the background level, respectively.

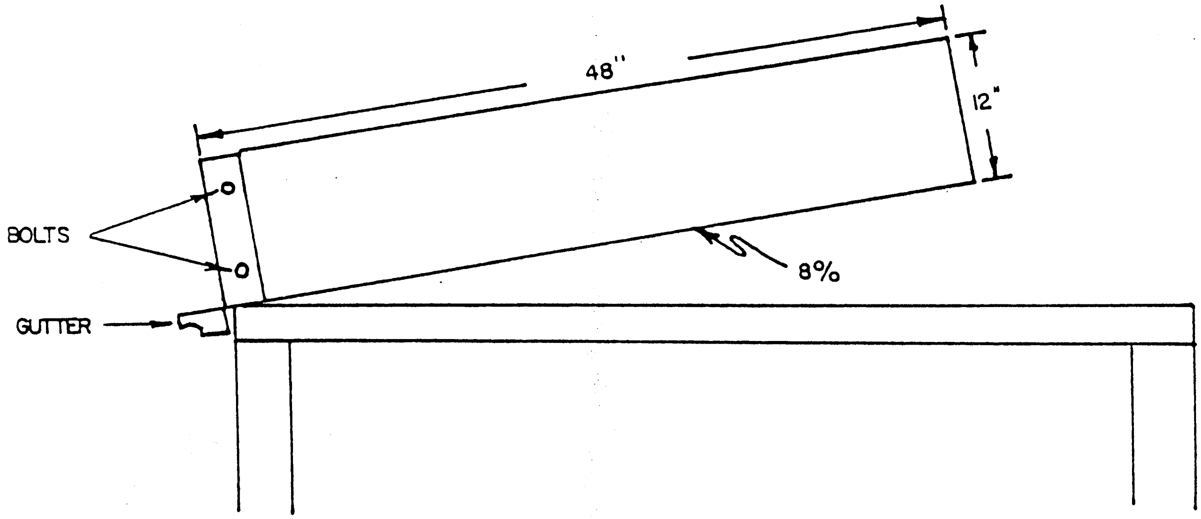
n. Repeat steps e through m for the same piece of fabric twice more.

o. Obtain two more fabric samples and repeat the entire procedure for each one.

p. Average the results of the nine tests as illustrated in Appendix A.

FIG. 1

FLUME - SIDE VIEW



FLUME - TOP VIEW

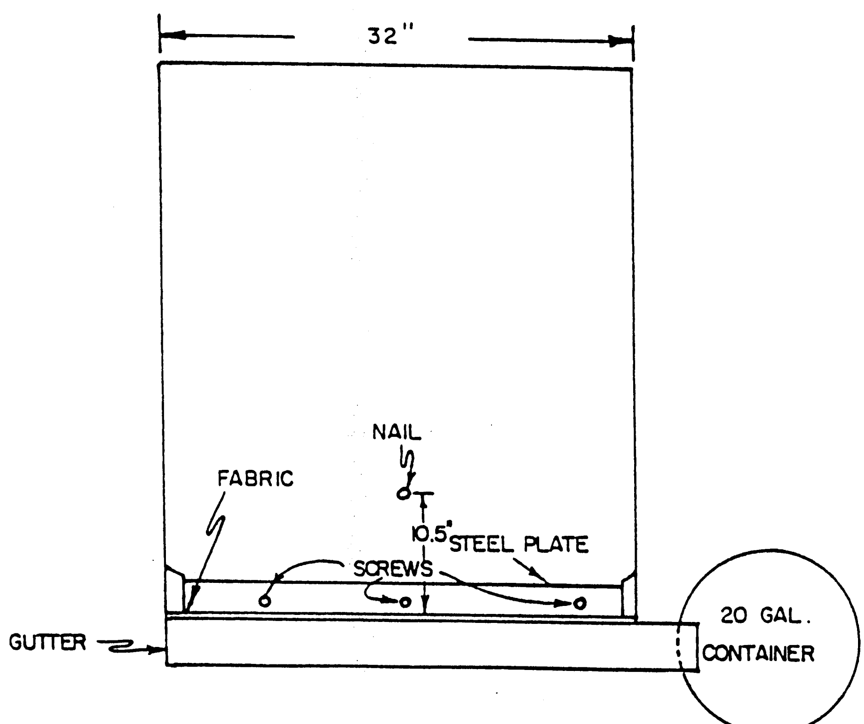
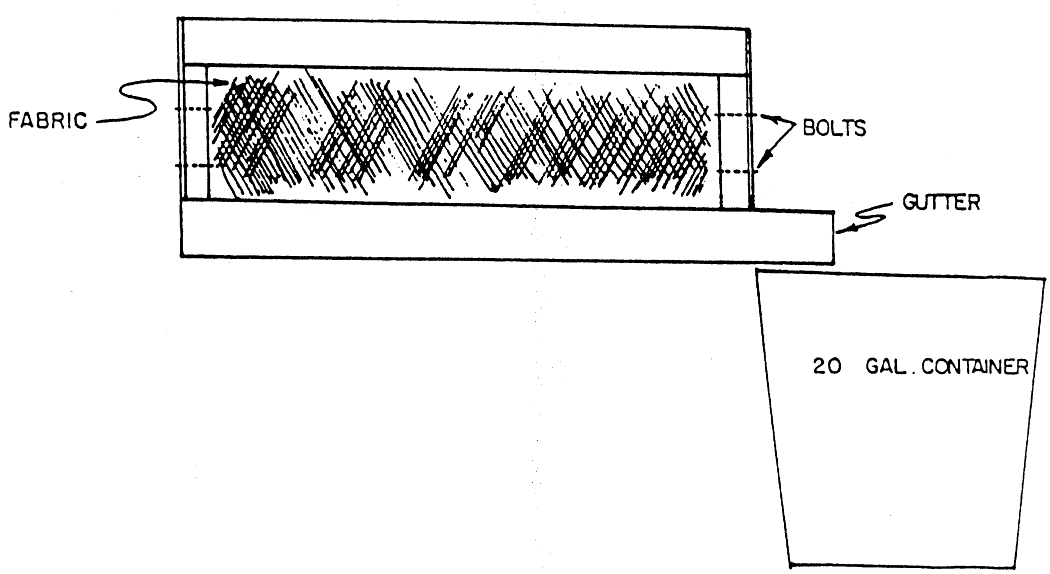


FIG. I CONT.

FLUME - END VIEW



NOTE...(1) ALL FLUME DIMENSIONS ARE INSIDE MEASUREMENTS
(2) 2 SIDE PLATES AND A BOTTOM PLATE ARE USED TO FASTEN THE SAMPLE OF FABRIC IN PLACE

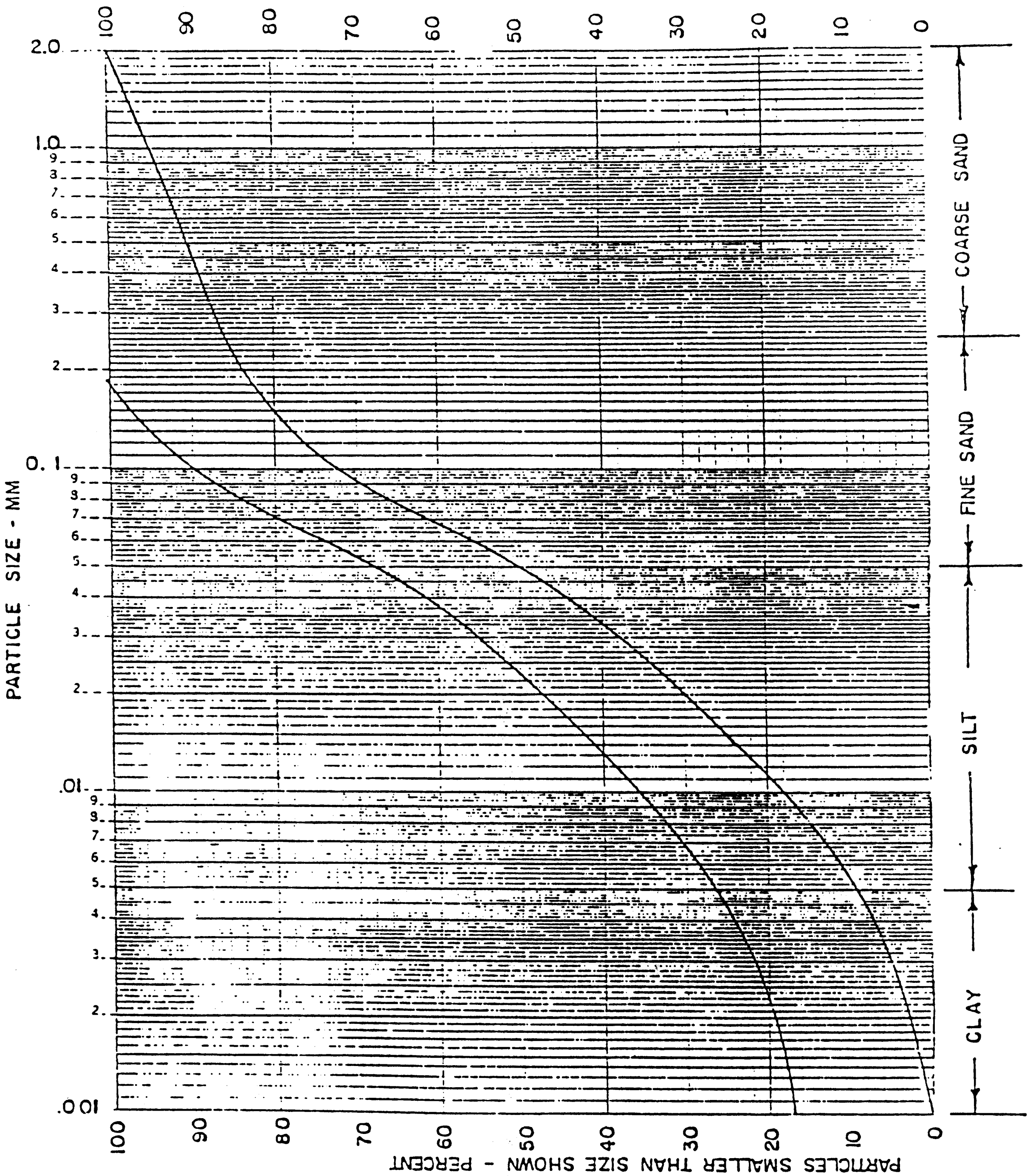

PARTICLE SIZE - MM
2.0
1.0
0.1
.01
.001
100 90 80 70 60 50 40 30 20 10 0
PARTICLES SMALLER THAN SIZE SHOWN - PERCENT
COARSE SAND
FINE SAND
SILT
CLAY

FIGURE 2.

Appendix A

Example of Flow Rate & Filtering Efficiency Calculations:

Flow Rate (Example Time)

Sample No. 1, Piece No. 1

1st 150 Grams Soil & Water =	8.62 Min.	Therefore 14.85/8.62	= 1.72
2nd 150 Grams Soil & Water =	19.22 Min.	Therefore 14.85/19.22	= 0.77
3rd 150 Grams Soil & Water =	25.45 Min.	Therefore 14.85/25.45	= 0.58

Sample No. 1, Piece No. 2

1st 150 Grams Soil & Water =	7.93 Min.	Therefore 14.85/7.93	= 1.87
2nd 150 Grams Soil & Water =	18.27 Min.	Therefore 14.85/18.27	= 0.81
3rd 150 Grams Soil & Water =	33.26 Min.	Therefore 14.85/33.26	= 0.45

Sample No. 1, Piece No. 3

1st 150 Grams Soil & Water =	14.87 Min.	Therefore 14.85/14.87	= 1.00
2nd 150 Grams Soil & Water =	18.45 Min.	Therefore 14.85/18.45	= 0.80
3rd 150 Grams Soil & Water =	33.88 Min.	Therefore 14.85/33.88	= 0.44
		Total	= 8.44

Flow Rate = 8.44/9 = 0.94 gal./sq. ft./min. (Average)

Filtering Efficiency

Same procedure for averaging as above using the formula for Filtering Efficiency.

APPENDIX B

ASTM TEST METHOD D5141

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St. Philadelphia, Pa 19103
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If not listed in the current combined index, will appear in the next edition.

Standard Test Method for Determining Filtering Efficiency and Flow Rate of a Geotextile for Silt Fence Application Using Site-Specific Soil[1]

This standard is issued under the fixed designation D 5141; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method is used to determine the filtering efficiency and the flow rate of a geotextile used exclusively in silt fence or silt barrier application.

NOTE 1—The terms silt fence and silt barrier are used synonomously.

1.1.1 The results are shown as a percentage for filtering efficiency and cubic metres per square metre per minute (m^3/m^2/min) or gallons per square foot per minute (gal/ft^2/min) for flow rate.

1.1.2 The filtering efficiency indicates the percent of sediment removed from sediment-laden water.

1.1.3 The flow rate is the average rate of passage of the sediment-laden water through the geotextile.

1.2 This test method requires several specialized pieces of equipment, such as an integrated water sampler and an analytical balance, and site specific soil from the construction project.

1.3 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 The values stated in SI units are the standard, while the inch-pound units are provided for information. The values expressed in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

2. Referenced Documents

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textile Materials[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3]

D 4439 Terminology for Geosynthetics[3]

D 4354 Practice for Sampling of Geosynthetics for Testing[3]

D 4759 Practice for Determining the Specification Conformance of Geosynthetics[3]

2.2 *American Public Health Association (APHA) Standard:*

208D Total Nonfiltrable Residue Dried at 103–105°C (Total Suspended Matter)[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *filtration*—See *filter.*

3.1.2 *filter*—See Terminology D 653.

3.1.3 *geosynthetic, n*—a planar product manufactured from polymeric material used with foundation soil, rock, earth, or any other geotechnical engineering related material as an integral part of a man-made project, structure, or system. (See Practice D 4759.)

3.1.4 *geotextile, n*—any permeable textile material used with foundation, soil, rock, earth, or any other geotechnical engineering related material, as an integral part of a man-made project, structure, or system.

3.1.5 *performance property, n*—a result obtained by conducting a performance test.

3.1.6 *performance test, n—in geosynthetics*, a laboratory procedure which simulates selected field conditions which can be used in design.

3.1.7 For definitions of other terms relating to geosynthetics, refer to Terminology D 4439. For definitions of textile terms, refer to Terminology D 123. For definitions of soil terms, refer to Terminology D 653.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *filtering efficiency, FE, n—in geosynthetics*, the percent of sediment removed from sediment-laden water by a geotextile over a specified period of time.

3.2.2 *flow rate, FR* $[L^3L^{-2}T^{-1}]$, *n—in geosynthetics*, the volume of fluid per unit time, expressed as an average, which passes through a cross-sectional plane perpendicular to the fluid flow.

3.2.3 *flume, n*—an apparatus that carries a liquid to an outlet.

3.2.4 *silt fence, n—in geosynthetics*, a temporary sediment control measure used to remove soil from runoff.

4. Summary of Test Method

4.1 A geotextile specimen is placed across a flume while sediment-laden water is passed through the specimen.

4.1.1 The time that water flows through the geotextile and the amount of soil passed by the geotextile are measured. The amount of soil retained, filtering efficiency, and flow rate are calculated from these measured values.

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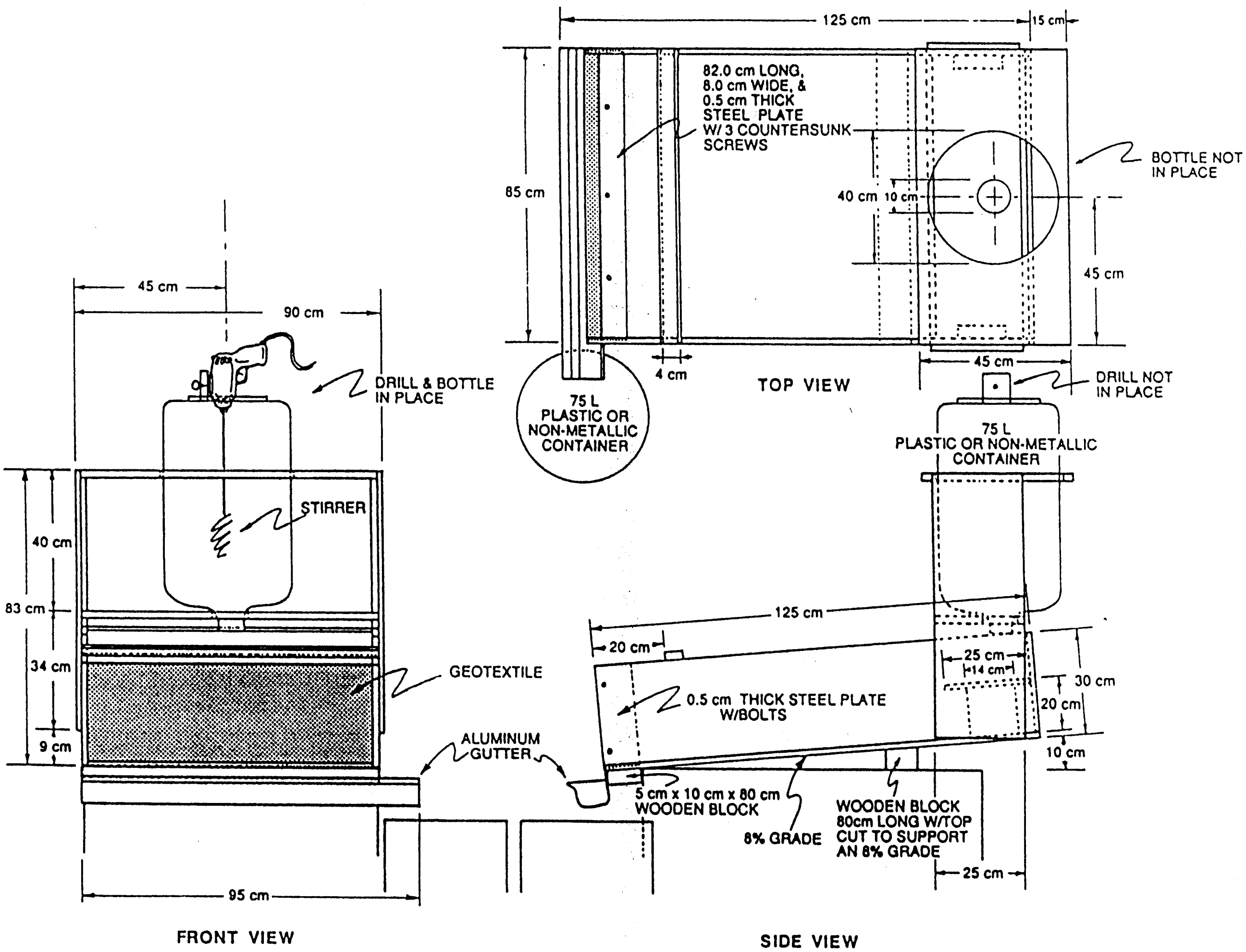
[1] This test method is under the jurisdiction of ASTM Committee D-35 Geosynthetics and is the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

Current edition approved March 27, 1991. Published May 1991.

[2] *Annual Book of ASTM Standards*, Vols 07.01 and 07.02.

[3] *Annual Book of ASTM Standards*, Vol 04.08.

[4] Available from American Public Health Association (APHA), 1015 Eighteenth St. NW, Washington, DC 20036.



NOTE—Sides and bottom of flume can be constructed of 2-cm thick marine grade plywood.

FIG. 1 Flume

4.2 Soil from the construction project should be used in this test method.

5. Significance and Use

5.1 This test method is used to determine the filtering efficiency and flow rate of a geotextile used in a silt fence or silt barrier installation for specific soil conditions.

5.2 This test method may be used for the design of a silt fence or silt barrier to meet requirements of regulatory agencies in filtering efficiency or flow rate for specific soil conditions.

5.2.1 The designer can use this test method to determine the spacing between silt fences or silt barriers.

5.3 This test method is intended for performance evaluation, as the results will depend on the specific soil evaluated. It is recommended that the user or representative perform the test to pre-approved products, as geotextile manufacturers are not typically equipped to handle or test soil requirements.

5.4 This test method provides a means of evaluating geotextiles with different soils under various conditions that simulate the conditions that exist in a silt fence or silt barrier installation. This test method may be used to simulate several storm events on the same geotextile specimen. Therefore, the number of times this test is repeated per specimen is dependent upon the user and the site conditions.

6. Apparatus

6.1 *Flume*, constructed from marine-grade plywood, plexiglas, aluminum, or other material. The flume should be watertight and constructed as shown in Fig. 1.

NOTE 2—Metal flumes should be mounted on a wood frame. The flume opening is the standard length of a straw bale. With a standard length flume of 122 cm (48 in.), the height of the back of the flume would be elevated 10 cm (3⅞ in.).

6.2 *Sample Cutter*, appropriate to prepare test specimens.

6.3 *Integrated Water Sampler*,[5] a 500-mL (0.13-gal) device used to collect integrated samples of water.

[5] The US DH-48 integrated water sampler has been found to be satisfactory. It is available from the Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, 3rd Avenue S.E., Minneapolis, MN 55414.

6.4 *Two Containers*, 75-L (20-gal), plastic or nonmetallic.

6.5 *Stopwatch.*

6.6 *Stirrer*, such as a stirring rod on a portable electric drill.

6.7 *Sediment-Free Water*, containing no flocculent agents.

NOTE 3—Flocculent agents used in water treatment may cause erroneous results by affecting the settling rate of soil particles in the water.

6.8 *Soil*, site-specific.

6.9 *Gooch Crucible.*

6.10 *Membrane Filter Apparatus.*

6.11 *Vacuum Pump.*

6.12 *Planchet*, aluminum or stainless steel.

6.13 *Desiccator.*

6.14 *Analytical Balance*, sensitivity of 0.00001 g.

7. Sampling

7.1 *Geotextile:*

7.1.1 *Lot Sample*—Divide the product into lots and take the lot sample as directed in Practice D 4354.

7.1.2 *Laboratory Sample*—After first discarding a minimum of 1 m (3.3 ft) of geotextile from the end of the roll, cut off sufficient length of the roll to get the appropriate number of test specimens. If holes or damaged areas are evident, then damaged material should be discarded and additional material sampled.

7.1.3 *Test Specimens*—Cut the appropriate number of specimens to be tested from the machine direction of the laboratory sample by a random method. Each test specimen should be cut (1 m long by 0.3 m wide [3.3 ft long by 12 in. wide] to fit the flume.

NOTE 4—No specimen should be within 0.2 m (6 in.) of a selvage.

7.2 *Soil*—Obtain representative samples of the site-specific soil that is significant to the design of the silt barriers or silt fences on the construction project. The size and type of sample required is dependent upon the number of tests to be performed and the percent of coarse particles in the sample.

8. Procedure

8.1 Place the geotextile tautly across the flume opening and fasten securely in place to ensure that the test specimen has no wrinkles or loose sections.

8.2 Elevate the back of the flume to an 8 % slope. (See Fig. 1.)

8.3 Pre-wet the geotextile by running one test with 50 L (13.3 gal) of sediment-free water. Record the temperature of the water.

8.4 Mix 0.15 kg (0.33 lb) of the site-specific soil in 50 L (13.3 gal) of untreated water placed in a 75-L (20-gal) container. These soil particles are smaller than 2 mm, the opening size of a No. 10 sieve. Thoroughly agitate the solution with a stirrer for 1 min to obtain a uniform mix.

8.5 While continuing to mix the solution, release the sediment-laden water at the upper end of the flume. Release of the solution should take less than 10 s. Start the timer at release.

8.6 Rinse the mixing container with no more than 2 L (0.5 gal) of additional water and release into the flume.

8.7 Time the flow of water through the geotextile until no water remains behind the geotextile or 25 min has elapsed. If 25 min have elapsed and water remains behind the geotextile, then measure the distance from the geotextile to the edge of the water behind the geotextile.

8.8 Collect all filtrate caught by the gutter in a second container, until no water remains behind the geotextile or 25 min has elapsed.

8.9 At the completion of the test, agitate the collected filtrate with a stirrer until the mixture is uniformly mixed. After 1 min of mixing, obtain a depth-integrated suspended-solids sample from the mixture while continuing the agitation.

NOTE 5—With the sampler specified in 6.3, a rate of sampling that requires 30 s to reach the bottom of the container and 30 s to return to the surface is ideal. This sampling procedure allows collection of a sample over the full depth of the mixture.

8.10 Place a glass fiber filter disk either on a membrane filter apparatus or in the bottom of a suitable Gooch crucible. Apply a vacuum and wash the disk with three successive 20-mL portions of distilled water. Continue suction to remove all traces of water from the disk.

8.11 Carefully remove the filter disk from the membrane filter apparatus and transfer to an aluminum or stainless steel planchet. If a Gooch crucible is used, remove the crucible and filter disk combination.

8.12 Dry the filter disk for at least 1 h in an oven at 103 to 105°C.

8.13 Store in a desiccator until cooled to room temperature.

8.14 Weigh the filter disk to an accuracy of 0.00001 g.

8.15 Place the filter disk in the membrane filter apparatus and return it or the Gooch crucible to the vacuuming and filtering apparatus.

8.16 Under the vacuum, filter the sample of water collected in 8.9.

8.17 Repeat 8.11 through 8.14.

9. Calculation

9.1 Calculate suspended solids, as follows:

$$S_S = \frac{(A - B) \times 1000}{C} \quad (1)$$

where:

S_S = suspended solids, ppm,
A = weight of filter plus residue, and
B = weight of filter, and
C = sample, mL.

9.2 Calculate the percent filtering efficiency (F_E) for the geotextile specimen, as follows:

$$F_E = \frac{2890 - S_s}{2890} \times 100 \quad (2)$$

where:

S_S = suspended solids after filtration, ppm, (Eq 1), and
2980 = sediment placed behind the geotextile, ppm.

9.3 Calculate the flow rate (F_T) of the geotextile specimen using Eq 3 (complete drainage) or Eq 4 (25 min elapsed time):

$$F_T\,(m^3/^2/min) = 0.6589/t \quad (3)$$

or

$$F_T\,(\mathrm{m^3/m^2/min}) = \frac{0.5623 - 0.00024x^2}{0.8533 - 0.01778x}\,t \quad (4)$$

where:
T = temperature of the water,
t = time measured in 8.7, min, and
x = distance from the geotextile to the edge of the water behind the geotextile (see 8.7).

9.3.1 Correct the flow rate to 20°C using Eq 5:

$$F_{20^\circ C} = \frac{F_T U_T}{U_{20^\circ C}} \quad (5)$$

where:
$\frac{U_T}{U_{20^\circ C}}$ = ratio of viscosity of water at temperature T to viscosity of water at 20°C (see Fig. 2).

10. Report

10.1 The report of filtering efficiency and flow rate should include the following information:

10.1.1 State that the specimens were tested as directed in this test method, and describe the type of geotextile tested and the sampling method used,

10.1.2 The number of specimens tested and the direction(s) tested (if applicable),

10.1.3 The type of soil used and any data showing pertinent physical properties of the soil, such as gradation curve, Atterberg limits, etc.,

10.1.4 Complete test data including temperature of the water, recorded flow rates, length of test (25 min or elapsed time), suspended solids contents, and filtering efficiencies for each trial, and

10.1.5 A statement of any deviation from the described test method.

11. Precision and Bias

11.1 *Precision*—The precision of the procedure in this test method for measuring filtering efficiency and flow rate of a geotextile is being established.

11.2 *Bias*—The procedure in this test method for measuring filtering efficiency and flow rate of a geotextile has no bias because the values of those properties can be defined only in terms of a test method.

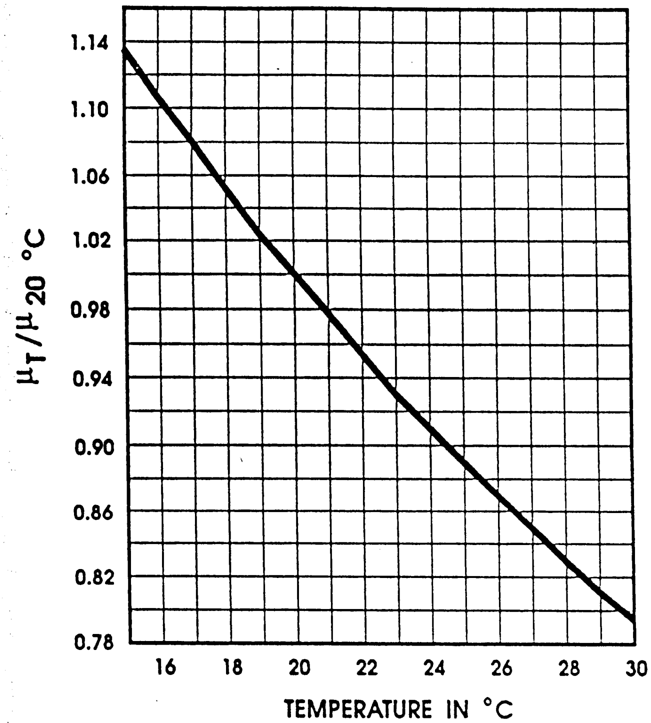


FIG. 2 The Ratio of Viscosity of Water at Temp, *T*, to the Viscosity of Water at 20°C

12. Keywords

12.1 filtering efficiency; flow rate; silt barrier; silt fence or

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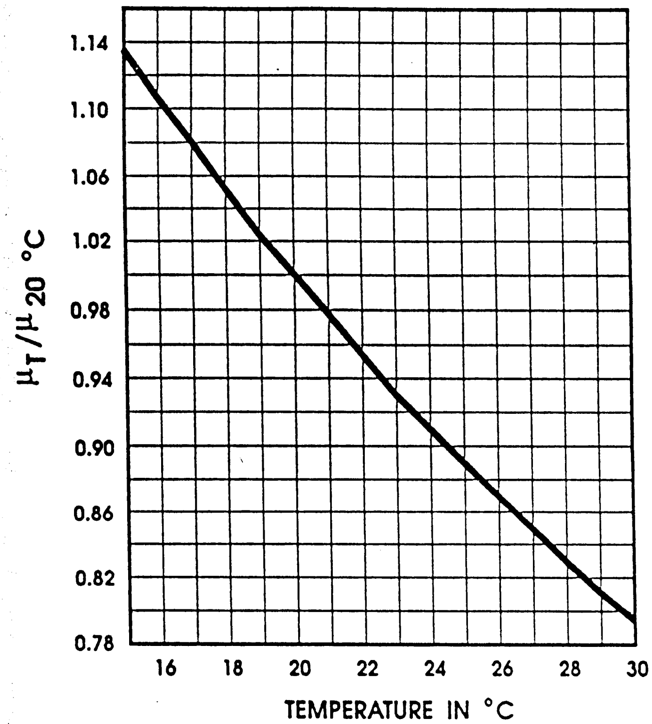

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