Geotextile Specifications for Highway Applications

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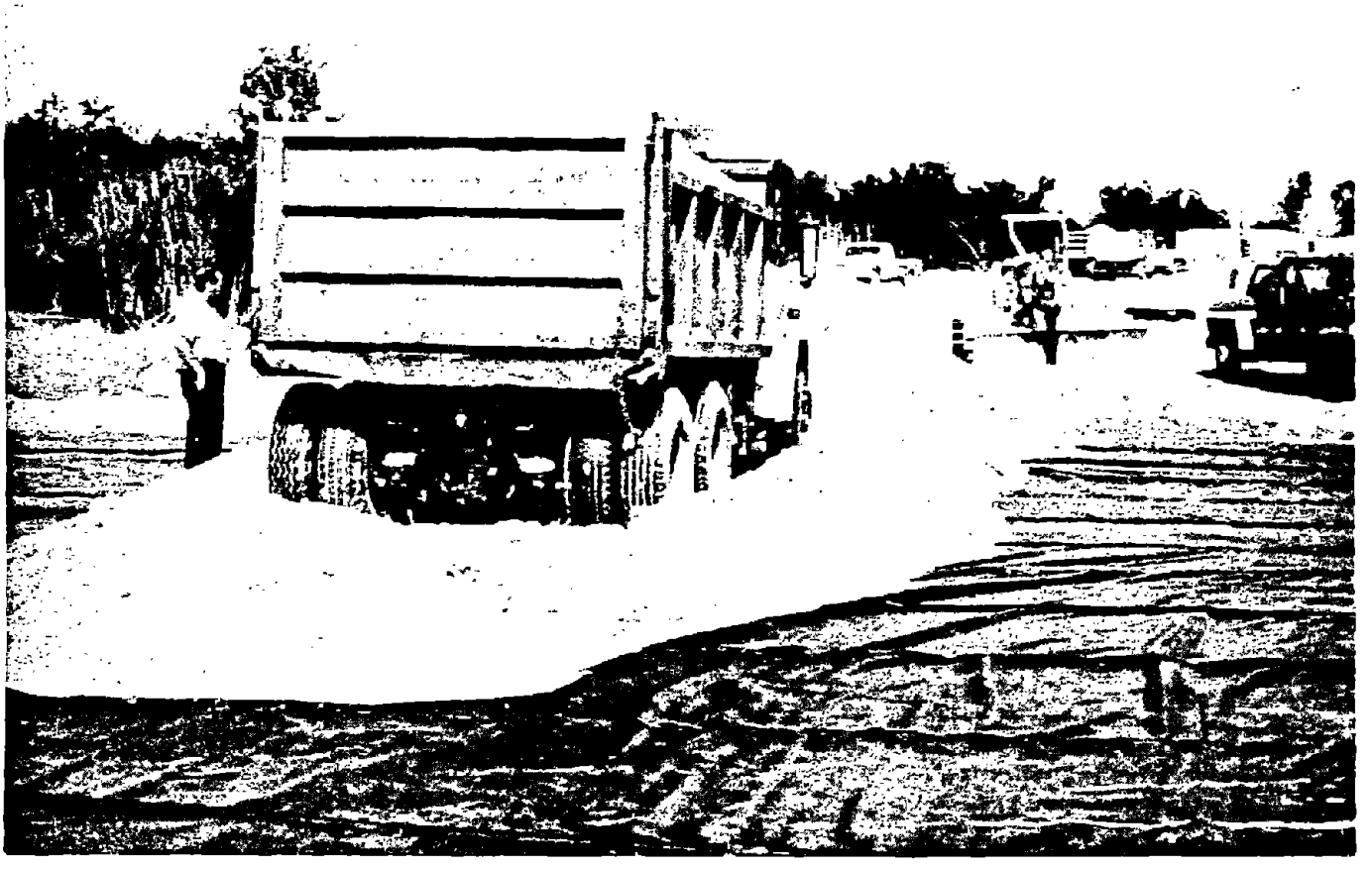

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FOREWORD

This Technology-Sharing Report provides a summary of geotextile specifications from 46 State highway agencies. It includes comments on required property values, individual State specifications, and an example of a generic geotextile specification. The report will be of interest to highway engineers and specification writers involved in design and construction of highway facilities using geotextile materials.

Additional copies of the publication can be obtained from the National Technical Information Service, Springfield, Virginia 22161.

Stanley R. Byington, Director
Office of Implementation

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16. Abstract

This document has been developed after review of 46 of the 52 (50 States, District of Columbia and Puerto Rico) State Agencies who responded to our request for their most recent specifications on geotextiles and related geosynthetic materials. The original requests were sent March 16, 1987, with follow up requests in April of 1988. From the excellent and cooperative response we feel that a representative sample has indeed been realized.

After an introduction, the report focuses on required property values, general details, individual State specification comparisons and conclusions. This main body of the report is purposely made quite brief.

The report continues with a sample generic geotextile specification. It is quite detailed and includes all features which we feel necessary for proper use of geotextiles in highway applications. The sample specification does not recommend numeric product values in the "property requirements" section. This is purposely left to the individual State agency, or other specifying group, since numeric values are both geographic dependent and site specific. Such values also reflect the philosophy of the specifying agency; ranging from extreme conservatism in required properties to extreme concern over costs.

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CHAPTER 1 - GEOTEXTILE SPECIFICATIONS FOR HIGHWAY APPLICATIONS

Introduction

Over the past two decades, the use of geosynthetics (geotextiles and related materials) within the field of Transportation Engineering has grown at a tremendous pace. Currently, geosynthetics are primarily used in transportation applications to provide for the following:

- separation of roadbed materials,
- drainage/filtration of roadbed materials, riprap, retaining walls and abutments,
- control of reflective cracking in bituminous concrete pavement overlays,
- retention of sediment resulting from the erosion of destabilized cover soil produced during construction activities,
- reduction of the effect that erosion has on embankment side slopes, within channels, streams and culverts during post construction,
- stabilization/reinforcement of slopes, embankments and soft soils, and
- construction of geotextile or geogrid reinforced retaining walls.

The Geosynthetic Research Institute (GRI) was commissioned by the U.S. Federal Highway Administration (FHWA) to assess the individual State's progress in keeping up with current geosynthetic activity and specifications. The main goal of this commission was to prepare a technical evaluation of State DOT specifications on geosynthetics, (geotextile applications in particular) which will assist State agencies in their own critique and possible improvement of current specifications. The initial portion of this report focuses on current specification information provided to GRI by 46 of the 52 (50 States, District of Columbia and Puerto Rico) State agencies whose specifications are stored in GRI's computer data base.

Each State's specifications were reviewed with regard to required property values, development of general details and an overview of the areas in which various geosynthetics are employed by State agencies. This report is framed into these different sections. In addition, a closing section entitled "Sample Generic Geotextile Specification" has been included to provide State agencies with the framework for future development of their specifications. It is hoped that the proper use of this information will aid State agencies in evaluation of their current specifications. This, in turn, should lead to the efficient use of geotextiles in future transportation related projects.

CHAPTER 2 - REQUIRED PROPERTY VALUES

Although there are many areas where geotextiles may be used in transportation related construction, there are six application areas which are most often referenced:

- survivability/separation,
- drainage/filtration,
- temporary erosion control (silt fences),
- control of reflective cracking,
- permanent erosion control, and
- embankment stabilization/reinforcement.

Each State specification was examined for its development which covers the initial five of these applications. The last one mentioned, embankment stabilization/ reinforcement is a site specific application which is usually covered under a special provision specification. Further, each State's minimum physical, mechanical, hydraulic and durability test methods and property values associated with each application area were compared with guidelines established by American Association of State Highway and Transportation Officials (AASHTO) and Task Force #25. This latter organization is a working group under the direction of a joint committee which includes AASHTO, the Associated General Contractors (AGC), and the American Road and Transportation Builders' Association (ARTBA).

The applicable test methods and required geotextile test values that were used to make the comparison are listed in Table 1. Complete AASHTO specifications are found in Appendix B and complete Task Force #25 specifications are given in Appendix C.

A comparison of the State specifications surveyed, versus these two specifications, is given in Table 2. The contents of Table 2 were formulated on the basis of information provided in Tables 3 through 7, each of which covers one of the application areas mentioned above.

Table 1. Summary of AASHTO and TF #25 Geotextile Recommendations

I. SURVIVABILITY/SEPARATION

	GRAB (lb)	PUNCTURE (lb)	BURST (lb/in^2)	TEAR (lb)
AASHTO	D1682 ≥ 90	D751 ≥ 170	----------	----------
TF #25	D4632 90 - 270*	D3787 30 - 110*	D3786 145 - 430*	D4533 30 -75*

II. DRAINAGE/FILTRATION

	GRAB (lb)	ELONG (%)	SEAM (lb)	PUNCTURE (lb)	BURST (lb/in^2)	TEAR (lb)	AOS/EOS (U.S. Sieve)	PERM (cm/sec)	UV (%)
AASHTO	D1682 ≥ 90	D1682 ≥ 20	-------	CW-02215 ≥ 45 l	D751 ≥ 140	D1117 ≥ 45	CW-02215 40 - 100	M288 0.01	-----
TF #25	D4632 80-180	D4632 N/A	D4632 70-160	D751 25-80	D3787 130-290	D3786 25-50	D4751 ‡	D4491 $K_P > K_S$	D4355 70-100%

III. SILT FENCE

	TENSILE (lb)	ELONG (%)	PERMITTIVITY†	AOS/EOS (U.S. Sieve)	UV (%)
AASHTO	D1682 ≥ 90	D1682 ≥ 20	M288 0.01 cm/sec	CW-02215 40-100	-----
TF #25	D4632 ≥ 90	D4632 0-50	D4491&VTM-51 ≥ 0.01 sec^{-1}	D4751 20 maximum	D4355 70-100

IV. REFLECTIVE CRACKING

	TENSILE (lb)	ELONG (%)	ASPHALT RET. (gal/yd^2)	MELT POINT (°F)
AASHTO	D1682 ≥ 90	D1682 ≤ 40	TexDOT 3002 .14 - 1.2	----------
TF #25	D4632 ≥ 80	D4632 ≥ 50	TexDOT 3002 ≥ 0.2	D276 ≥ 300

V. EROSION CONTROL

	GRAB (lb)	ELONG (%)	SEAM (lb)	PUNCTURE (lb)	BURST (lb/in^2)	TEAR (lb)	AOS/EOS (U.S. Sieve)	PERM (cm/sec)	UV (%)
AASHTO	D1682 ≥ 90	D1682 ≥ 20	-------	CW-02215 ≥ 45	D751 ≥ 140	D1117 ≥ 45	CW-02215 40 - 100	M288 0.01cm/s	-----
TF #25	D4632 90-200	D4632 ≥ 15	D4632 80-180	D3787 40-80	D3786 140-320	D4533 30-50	D4751 ‡	D4491 $K_f > K_S$	D4355 70-100

†AASHTO uses the falling head test to determine permeability while TF #25 uses ASTM constant head testing to determine geotextile permittivity which is then multiplied by the fabric thickness to obtain the fabric permeability.

‡For soil with 50% or less particles by weight passing U.S. No. 200 sieve, AOS < 0.6 mm (greater than #30 U.S. sieve). For soil with more than 50% particles by weight passing U.S. No. 200 sieve, AOS < 0.297 mm (greater than #50 U.S. sieve).

*Values established by TF #25 are interim property values

Table 2. State Specification Topic Areas and Comparisons with AASHTO and TF #25

		TOTAL NO.	Reference Table
I.	SURVIVABILITY/SEPARATION		
	STATES ADDRESSING THIS TOPIC	14	3
	STATES FOLLOWING		
	AASHTO	9	
	TASK FORCE #25	4	
II.	DRAINAGE/FILTRATION		
	STATES ADDRESSING THIS TOPIC	27	4
	STATES FOLLOWING:		
	AASHTO	6	
	TASK FORCE #25	0	
III.	SILT FENCE		
	STATES ADDRESSING THIS TOPIC	11	5
	STATES FOLLOWING:		
	AASHTO	0	
	TASK FORCE #25	2	
IV.	REFLECTIVE CRACKING		
	STATES ADDRESSING THIS TOPIC	10	6
	STATES FOLLOWING:		
	AASHTO	2	
	TASK FORCE #25	1	
V.	EROSION CONTROL		
	STATES ADDRESSING THIS TOPIC	26	7
	STATES FOLLOWING:		
	AASHTO	4	
	TASK FORCE #25	4	

Table 3. Individual State Geotextile Property Values for Survivability/Separation Applications

State	Grab Strength (lbs.)	Puncture Strength (lbs.)	Burst Strength ($lb./in.^2$)	Trap Tear (lbs.)
AK	90	30	170	25
AL				
AR				
AZ				
CA				
CO				
CT				
DC				
DE				
FL				
GA				
HI				
IA				
ID	180	80	290	50
IL				
IN				
KS				
KY				
LA				
MA				
MD	90		145	
ME				
MI	90	45	140	45
MN	90			
MO				
MS				
MT				
NC				
ND	180	75	290	50
NE				
NH				
NJ	125			
NM	90		200	50
NV				
NY				
OH				
OK				
OR	180	80	290	
PA	270	110	430	75
PR	200			
RI				
SC				
SD				
TN				
TX	100			
UT				
VA				
VT				
WA				
WI	150	50	200	
WV				
WY	90	75	290	50

Table 4. Individual State Geotextile Property Values for Drainage (Filtration) Applications

State	Grab (lbs.)	Elongation (%)	Seam (lbs.)	Puncture (lbs.)	Burst ($lb./in.^2$)	Trap (lbs.)	AOS/EOS (Sieve No.)	Permeability (cm/sec)	UV (% Ret.)
AK	90	15			125		40	.010	90
AL	90	20		45	140	45	40	.010	
AR									
AZ									
CA	50	10							
CO									
CT									
DC									
DE									
FL	90	20	90	60	200	35	50	.020	
GA									
HI									
IA		20					50	.020	35
ID	90	20		40	100	45	70	.100	
IL	50	20			100		30		
IN									
KS									
KY	80		70	25	130	25	40	.025	70
LA	75						50	8.000	
MA									
MD									
ME	80	15		25	130	25	20	.010	
MI	100	20		45	140	45	40	.020	
MN	90	20		45	140	45	40	.700	
MO									
MS	90	20		45	140	45	40	.010	
MT	90	20		40	100	45	40	.100	
NC									
ND	180	80		80	290	50	70	.100	
NE	90	20		45	140	45	40	.010	
NH									
NJ	125								
NM	90		200	50					
NV									
NY									
OH	80			25	130	25	50	.010	
OK									
OR	80	15		80	130		50		
PA	90	20		40	150	50	40	.010	
PR	90	20		70	140		40	.100	
RI									
SC									
SD	200	50		120	400		70		
TN									
TX									
UT	100	95		30	125		70	.020	
VA	25	20					30	.510	
VT									
WA	90		80	40	140	30	70	.080	
WI	75	20		50	150			.100	
WV	100	30		35	130	35	50	.010	
WY	40	20	40	25	130	25	30	.100	

Table 5. Individual State Geotextile Property Values for Temporary Silt Fence Applications

State	Tensile Strength (lbs.)	Elongation (%)	Permittivity (sec^{-1})	AOS/EOS (Sieve No.)	Ultraviolet (% Ret.)
AK					
AL	90	15			
AR					
AZ					
CA					
CO					
CT					
DC					
DE					
FL					
GA					
HI					
IA	100				35
ID					
IL	200	15		50	
IN					
KS					
KY					
LA					
MA					
MD					
ME					
MI					
MN					
MO					
MS					
MT	120	20	.010		90
NC					
ND					
NE					
NH					
NJ	100	10	.010		
NM					
NV					
NY					
OH	120		.010	50	90
OK					
OR					
PA	120	15			
PR					
RI					
SC					
SD					
TN					
TX	80	35	.200	35	
UT					
VA	30	20			
VT					
WA	90	30	.005	20	70
WI					
WV	90	15			
WY					

Table 6. Individual State Geotextile Property Values for Reflective Cracking Applications

State	Tensile Strength (lbs.)	Elongation (lbs.)	Asphalt Retention (gal/yd^2)	Melting Point (lbs.)
AK	90	150	.20	
AL				
AR				
AZ				
CA	90	40		
CO				
CT				
DC				
DE				
FL	150	15	.30	
GA				
HI	78	50	.20	
IA	90	20		
ID	80	50		300
IL				
IN				
KS				
KY				
LA				
MA				
MD				
ME				
MI				
MN				
MO				
MS	180	50	.20	
MT				
NC				
ND				
NE				
NH				
NJ				
NM				
NV				
NY				
OH				
OK				
OR	80	50	.20	300
PA				
PR	100	40	.20	300
RI				
SC				
SD				
TN				
TX				
UT				
VA				
VT				
WA	80	50	.25	
WI				
WV				
WY				

Table 7. Individual State Geotextile Property Values for Permanent Erosion Control Applications

State	Grab (lbs.)	Elongation (%)	Seam (lbs.)	Puncture (lbs.)	Burst (lb./in.^{2})	Trap Tear (lbs.)	AOS (Sieve No.)	Permeability (cm/sec)	UV (% Ret.)
AK	90	15			125		50		90
AL	200		180	120	500		70	.020	
AR									
AZ									
CA	100	50							
CO									
CT									
DC									
DE									
FL	250	20	250	115	500	50	40	.020	80
GA									
HI									
IA	115	20					50	.020	
ID	200	15		80	320	50		.001	70
IL	200	15			250	75	50		
IN	200	15	180	80	320	50	30	.060	70
KS	100			60	250		40		
KY	200	15	180	80	320	50	40	.010	70
LA	190	10			300		30	8.000	75
MA									
MD									
ME	90	15		40	145	30	20	.010	
MI	200	20		45	250	45	40	.010	
MN	200	20		45	140	45	50	.300	
MO	200			80			70		
MS	200	20		80	300	65	40	.010	
MT	125	20		40	125	50	40	.010	
NC									
ND	200	35		80	320	50	70	.200	
NE									
NH									
NJ									
NM									
NV									
NY									
OH	200	20		80	320	50	30	.001	
OK									
OR	200	15		80	320		50		70
PA	200	15	120	40	20	50	40	.010	
PR									
RI									
SC									
SD									
TN									
TX									
UT									
VA	30	20		80			50		
VT									
WA	130	15	110	60	200	40	50	.050	70
WI	200	20		75	250		30	.400	
WV	150	20		60	250	40	50	.010	
WY	65	20	65	50	210	40	30	.100	90

The following summary comments are based on the foregoing body of information:

(a) There is considerable variation from State to State.

(b) The best progress to date is in the area of filtration where approximately 50% of the States' have specifications on drainage/filtration and permanent erosion control applications. This is to be expected since these were the original U.S. applications of geotextiles as developed by the Corps of Engineers in the late 1960's and early 1970's.

(c) Other geotextile application areas of survivability/separation, silt fence and reflective cracking have about 20% of the States taking a defined and quantified position.

(d) Of the States conforming to a guideline in any of the above areas, most follow AASHTO in preference to Task Force #25.

(e) Newer types of geosynthetics, e.g., geogrids, geonets, geomembranes and geocomposites, are essentially absent from State Specifications.

(f) Only one State takes a position on geogrids which are seeing wide use in reinforcement applications.

(g) Some States (e.g., Washington, Oregon, Montana and Maine) have taken a very positive and commendable position regarding their writing of geotextile specifications. Our sample specification at the conclusion of this report bears heavily on these States and selected portions of other State specifications as well.

CHAPTER 3 - DEVELOPMENT OF GENERAL DETAILS

Upon review of the totality of the various State's specifications, along with AASHTO and Task Force #25 documents, it is felt that there are seven sections which should be included for an adequate and proper geotextile specification:

- General requirements
- Certification
- Guarantee
- Shipment and Storage
- Sampling and Testing
- Basis of Property Requirements
- Basis of Payment

These topics are reviewed by quoting the applicable part of the AASHTO and/or TF #25 specifications and then comparing the statements to those used in the actual State specifications under review.

GENERAL REQUIREMENTS

Statement as per AASHTO

The geotextile fabric shall be a woven or nonwoven fabric consisting only of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. The fabric shall be inert to commonly encountered chemicals and conform to the requirements shown in the reference table.

Statement as per Task Force #25

Fibers used in the manufacture of geotextile, and the threads used in joining geotextiles by sewing, shall consist of long chain synthetic polymers composed of at least 85% by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selveges. These materials shall conform to the physical requirements shown in the reference table.

Table 8 - State's Position on Inclusion of a General Requirement Section and the Preferred Option

STATE	OPTION (See below)	STATE	OPTION (See below)
Alaska	B	North Carolina	G
Alabama	B	North Dakota	B
Arkansas	A	Nebraska	A
Arizona	A	New Hampshire	H
California	E	New Jersey	B
Colorado	E	New Mexico	E
Connecticut	I	Nevada	G
Dist. of Columbia	I	New York	H
Delaware	I	Ohio	E
Florida	B	Oklahoma	I
Georgia	I	Oregon	E
Hawaii	E	Pennsylvania	B
Iowa	E	Puerto Rico	B
Idaho	A	Rhode Island	F
Illinois	E	South Carolina	I
Indiana	D	South Dakota	A
Kansas	B	Tennessee	E
Kentucky	B	Texas	E
Louisiana	D	Utah	F
Massachusetts	F	Virginia	E
Maryland	D	Vermont	F
Maine	F	Washington	D
Michigan	A	Wisconsin	E
Minnesota	A	West Virginia	E
Missouri	D	Wyoming	B
Mississippi	D		
Montana	A		

Option	Description	No. States	Percent States
A.	Follows AASHTO exactly	8	15
B.	Follows AASHTO approximately	10	19
C.	Follows TF #25 exactly	0	0
D.	Follows TF #25 approximately	6	11
E.	Uses other	13	25
F.	None stated in specifications	5	10
G.	Site Specific	2	4
H.	Pre-approved	2	4
I.	Not Provided	6	11

CERTIFICATION

Statement as per AASHTO

The manufacturer shall file with the purchaser a certificate setting forth the name of the manufacturer, the chemical composition of the filaments or yarns, and other pertinent information so as to fully describe the geotextile. The certificate shall be attested to by a person having legal authority to bind the company. Either mismarketing or misrepresentation by the manufacturer shall be reason to discontinue acceptance under these specifications. Notice sent to the manufacturer by the purchaser regarding the discontinuance of acceptance will be considered to be notice to all wholesalers, jobbers, distributers, agents and other intermediaries handling the manufacturer's product.

Table 9 - State's Position on Inclusion of a Certificate Section and the Preferred Option

STATE	OPTION (See Below)	STATE	OPTION (See Below)
Alaska	D	North Carolina	F
Alabama	A	North Dakota	D
Arkansas	A	Nebraska	A
Arizona	A	New Hampshire	F
California	C	New Jersey	D
Colorado	C	New Mexico	D
Connecticut	G	Nevada	E
Dist. of Columbia	G	New York	F
Delaware	G	Ohio	D
Florida	C	Oklahoma	G
Georgia	G	Oregon	C
Hawaii	C	Pennsylvania	B
Iowa	D	Puerto Rico	C
Idaho	B	Rhode Island	D
Illinois	C	South Carolina	G
Indiana	D	South Dakota	C
Kansas	D	Tennessee	C
Kentucky	C	Texas	D
Louisiana	D	Utah	D
Massachusetts	D	Virginia	D
Maryland	D	Vermont	D
Maine	D	Washington	C
Michigan	A	Wisconsin	C
Minnesota	A	West Virginia	C
Missouri	C	Wyoming	D
Mississippi	C		
Montana	C		

Option	Description	No. States	Percent States
A.	Follows AASHTO exactly	6	11
B.	Follows AASHTO approximately	2	4
C.	Uses other	16	31
D.	None stated in specifications	18	34
E.	Site Specific	2	4
F.	Pre-approved	2	4
G.	Not Provided	6	11

GUARANTEE

Statement as per AASHTO

The manufacturer shall submit with the certificate of guarantee stating that the geotextile that is furnished meets the requirements of this specification. In addition, the manufacturer shall maintain test records as required by this specification. These records shall be made available to the purchaser upon request.

Table 10 - State's Position on Inclusion of a Guarantee Section and the Preferred Option

STATE	OPTION (See below)	STATE	OPTION (See below)
Alaska	D	North Carolina	E
Alabama	A	North Dakota	D
Arkansas	A	Nebraska	A
Arizona	A	New Hampshire	F
California	D	New Jersey	D
Colorado	D	New Mexico	D
Connecticut	G	Nevada	E
Dist. of Columbia	G	New York	F
Delaware	G	Ohio	D
Florida	D	Oklahoma	G
Georgia	G	Oregon	D
Hawaii	D	Pennsylvania	D
Iowa	D	Puerto Rico	D
Idaho	B	Rhode Island	D
Illinois	D	South Carolina	G
Indiana	D	South Dakota	D
Kansas	D	Tennessee	D
Kentucky	B	Texas	D
Louisiana	D	Utah	D
Massachusetts	D	Virginia	D
Maryland	D	Vermont	D
Maine	D	Washington	D
Michigan	A	Wisconsin	C
Minnesota	A	West Virginia	D
Missouri	D	Wyoming	D
Mississippi	D		
Montana	D		

Option	Description	No. States	Percent States
A.	Follows AASHTO exactly	6	11
B.	Follows AASHTO approximately	2	4
C.	Uses other	1	2
D.	None stated in specifications	33	63
E.	Site Specific	2	4
F.	Pre-approved	2	4
G.	Not Provided	6	11

SHIPMENT AND STORAGE

Statement as per AASHTO

During periods of shipment and storage, the fabric shall be protected from direct sunlight, ultraviolet rays, temperatures greater than 140 deg. F., mud, dirt, dust, and debris. To the extent possible, the fabric shall be maintained wrapped in a heavy-duty protective covering. Each shipping document shall include a notation certifying that the geotextile is in accordance with the manufacturer's certificate and guarantee previously filed with the purchaser.

Table 11 - State's Position on Inclusion of a Shipment and Storage Section and the Preferred Option

STATE	OPTION (See below)	STATE	OPTION (See below)
Alaska	D	North Carolina	E
Alabama	A	North Dakota	D
Arkansas	D	Nebraska	A
Arizona	A	New Hampshire	F
California	D	New Jersey	D
Colorado	C	New Mexico	D
Connecticut	G	Nevada	E
Dist. of Columbia	G	New York	F
Delaware	G	Ohio	B
Florida	C	Oklahoma	G
Georgia	G	Oregon	C
Hawaii	D	Pennsylvania	B
Iowa	B	Puerto Rico	B
Idaho	B	Rhode Island	D
Illinois	C	South Carolina	G
Indiana	D	South Dakota	D
Kansas	D	Tennessee	D
Kentucky	B	Texas	C
Louisiana	D	Utah	B
Massachusetts	D	Virginia	B
Maryland	D	Vermont	B
Maine	B	Washington	C
Michigan	A	Wisconsin	D
Minnesota	A	West Virginia	B
Missouri	D	Wyoming	B
Mississippi	C		
Montana	B		

Option	Description	No. States	Percent States
A.	Follows AASHTO exactly	5	10
B.	Follows AASHTO approximately	13	25
C.	Uses other	7	13
D.	None stated in specifications	17	33
E.	Site Specific	2	4
F.	Pre-approved	2	4
G.	Not Provided	6	11

SAMPLING AND TESTING

Statement as per AASHTO

The product shall be subject to sampling and testing. The sampling shall be by random basis per manufacturer's lot. Each lot sampled shall provide a sample of three (3) square yards size and all tests will be run in triplicate.

Table 12 - State's Position on Inclusion of a Sampling and Testing Section and the Preferred Option

STATE	OPTION (See below)	STATE	OPTION (See below)
Alaska	D	North Carolina	E
Alabama	A	North Dakota	D
Arkansas	A	Nebraska	A
Arizona	A	New Hampshire	F
California	D	New Jersey	D
Colorado	C	New Mexico	D
Connecticut	G	Nevada	E
Dist. of Columbia	G	New York	F
Delaware	G	Ohio	D
Florida	C	Oklahoma	G
Georgia	G	Oregon	C
Hawaii	C	Pennsylvania	C
Iowa	D	Puerto Rico	C
Idaho	C	Rhode Island	C
Illinois	D	South Carolina	G
Indiana	D	South Dakota	D
Kansas	D	Tennessee	D
Kentucky	C	Texas	C
Louisiana	D	Utah	C
Massachusetts	D	Virginia	D
Maryland	D	Vermont	C
Maine	E	Washington	C
Michigan	A	Wisconsin	C
Minnesota	A	West Virginia	D
Missouri	C	Wyoming	D
Mississippi	C		
Montana	C		

Option	Description	No. States	Percent States
A.	Follows AASHTO exactly	6	11
B.	Follows AASHTO approximately	0	0
C.	Uses other	17	33
D.	None stated in specifications	19	37
E.	Site Specific	2	4
F.	Pre-approved	2	4
G.	Not Provided	6	11

PROPERTY BASIS

GRI Comment: The basis for geotextile properties can be specified in a number of ways, e.g., average lot, minimum average roll or absolute minimum. The comparisons made in this table are meant to determine which concept a particular State uses in its specifications. Note should be made to the fact that Task Force #25 recommends use of minimum average roll values (MARV).

Table 13 - State's Position on Inclusion of a Property Basis Section and the Preferred Option

STATE	OPTION (See below)	STATE	OPTION (See below)
Alaska	B	North Carolina	E
Alabama	D	North Dakota	D
Arkansas	D	Nebraska	D
Arizona	D	New Hampshire	F
California	D	New Jersey	D
Colorado	B	New Mexico	D
Connecticut	G	Nevada	E
Dist. of Columbia	G	New York	F
Delaware	G	Ohio	B
Florida	B	Oklahoma	G
Georgia	G	Oregon	B
Hawaii	D	Pennsylvania	B
Iowa	D	Puerto Rico	B
Idaho	B	Rhode Island	D
Illinois	D	South Carolina	G
Indiana	B	South Dakota	D
Kansas	D	Tennessee	D
Kentucky	B	Texas	D
Louisiana	D	Utah	D
Massachusetts	D	Virginia	D
Maryland	B	Vermont	D
Maine	B	Washington	B
Michigan	B	Wisconsin	B
Minnesota	D	West Virginia	B
Missouri	D	Wyoming	D
Mississippi	D		
Montana	D		

Option	Description	No. States	Percent States
A.	Specified as average lot	0	0
B.	Specified as minimum average roll	16	31
C.	Specified as absolute minimum	0	0
D.	Nothing stated in specification	26	50
E.	Site Specific	2	4
F.	Pre-approved	2	4
G.	Not Provided	6	11

BASIS OF PAYMENT

Statement as per Task Force #25

The accepted quantities of geotextile shall be paid as follows:

(a) Erosion control geotextile per square yard.
(b) Drainage and Paving geotextile at the contract unit price per square yard in place.
(c) Silt fence geotextile per linear foot which shall be full compensation for completing the work specified. Such payment shall be full compensation for furnishing all materials, erecting, maintaining, and removing the fence

Table 14 - State's Position on Inclusion of a Basis of Payment Section and the Preferred Option

STATE	OPTION (See below)	STATE	OPTION (See below)
Alaska	B	North Carolina	E
Alabama	D	North Dakota	B
Arkansas	B	Nebraska	C
Arizona	D	New Hampshire	F
California	B	New Jersey	C
Colorado	B	New Mexico	B
Connecticut	G	Nevada	E
Dist. of Columbia	G	New York	F
Delaware	G	Ohio	D
Florida	C	Oklahoma	G
Georgia	G	Oregon	B
Hawaii	B	Pennsylvania	B
Iowa	D	Puerto Rico	D
Idaho	B	Rhode Island	C
Illinois	B	South Carolina	G
Indiana	B	South Dakota	D
Kansas	D	Tennessee	C
Kentucky	D	Texas	C
Louisiana	D	Utah	C
Massachusetts	D	Virginia	B
Maryland	D	Vermont	B
Maine	C	Washington	B
Michigan	D	Wisconsin	C
Minnesota	D	West Virginia	B
Missouri	C	Wyoming	B
Mississippi	C		
Montana	C		

Option	Description	No. States	Percent States
A.	Follows TF #25 exactly	0	0
B.	Follows TF #25 approximately	17	33
C.	Uses other	12	23
D.	None stated in specifications	13	25
E.	Site Specific	2	4
F.	Pre-approved	2	4
G.	Not Provided	6	11

Comments regarding conformance with the various descriptive statements of AASHTO and/or TF #25 just reviewed are as follows:

(a) Approximately 71% of State agencies include a general requirements statement as part of their specifications. Of this percentage, 25% use statements which differ from the statements that AASHTO and/or TF #25 recommend.

(b) Approximately 47% include a statement regarding material certification, with 31% of the agencies employing a statement different than the one established by AASHTO.

(c) Only 18% of the agencies surveyed require a statement of guarantee as recommended by AASHTO. Further, an additional 63% have not included any statement in this regard.

(d) Approximately 48% include a shipment and storage clause. An additional 33% do not include such a statement.

(e) Approximately 44% of the States surveyed included a statement concerning sampling and testing of geotextiles, with 33% using statements differing from AASHTO.

(f) Only 31% of the States address the basis for geotextile property determination. Those States that included a statement in this regard specify minimum average roll values which is in agreement with Task Force #25 recommendations.

(g) Approximately 56% of the States include a basis of payment statement covering the various geosynthetic applications.

(h) In general, it appears that there is a lack of uniformity in the overall details portion of the various State specifications.

CHAPTER 4 - OVERVIEW OF INDIVIDUAL STATE AGENCY SPECIFICATIONS - QUALITATIVE ASPECTS

This portion of the review on individual State agency specifications focuses on the qualitative, or non-numeric, aspects of the various State DOT specifications. It is meant to give a perspective on the breadth of the geosynthetics area as seen by individual States. Each of the State agencies surveyed were evaluated with regard to the following items:

- Application areas covered by specifications
- Nonstandard applications within specifications
- Geosynthetics mentioned other than geotextiles
- Design details included in specifications
- Good features of the specifications
- Misleading information within specifications

The authors' comments regarding the above listed topics follow.

(a) Most States cover the standard items of Separation, Drainage/Filtration, Temporary Erosion Control (Silt Fence), Reflective Cracking and Permanent Erosion Control.

(b) The additional applications and the State referring to same are the following:

1. Grade Point Drain, Idaho (ID)
2. Bulkhead and Flexible Revetment, Louisiana (LA)
3. Oil Fence, Massachusetts (MA)
4. Wrapping joints of concrete pipe culverts, Maryland (MD)
5. Brush Barriers, Montana (MT)

(c) The geosynthetics mentioned (other than geotextiles) were as follows:

1. Geogrids and Geowebs, Colorado (CO)
2. Three-Dimensional Mesh, Michigan (MI)
3. Erosion Control Netting, Nebraska (NE)
4. Strip (Wick) Drains, New Mexico (NM), New York (NY)
5. Prefabricated Structural Drains, New York (NY)
6. Plastic Liners or Geomembranes, Puerto Rico (PR)
7. Excelsior and Fabric Matting, Tennessee (TN)
8. Polypropylene Net Matting, Vermont (VT)
9. Geogrids, West Virginia (WV)

(d) In general, very few States include design details. Design details which were developed and the respective State or States which provided these details are as follows:

1. Silt Fence, Delaware (DE), South Carolina (SC) and Washington (WA)
2. Soft Soil Stabilization, Slope Protection, etc., Maine (ME)
3. Ditch and Stream Channel, Erosion Control, etc., Washington (WA)

(e) Many States have included interesting features which should be communicated to other States. We feel the following are the most significant in this regard:

1. Fabric Placement, Alaska (AK)
2. Seaming, California (CA), Idaho (ID), Maine (ME), and Oregon (OR)
3. Geogrid and Geoweb Placement, Colorado (CO)
4. Construction Requirements for Retaining Walls, Hawaii (HI)
5. Ground Stabilization and Silt Fence Specifications, Illinois (IL)
6. Sampling and Testing Section, Maine (ME)
7. Pavement Applications, Mississippi (MS)
8. Strip (Wick) Drain Specification, New Mexico (NM)
9. Definition Section, Oregon (OR), Puerto Rico (PR), Washington (WA), and Wisconsin (WI)
10. Survivability Designations, Washington (WA)
11. Product Labeling Section, Texas (TX)
12. Equipment Load Limits for Fabric Placement, Wyoming (WY)

(f) Awkward information that should generally be avoided is as follows:

1. Outdated Terminology, Arkansas (AR), Florida (RD), and Hawaii (HI)
2. Qualitative Specifications Only, Arizona (AZ), Michigan (MI)
3. Quantitative Specifications Only, Ohio (OH)

CHAPTER 5 - OVERVIEW OF INDIVIDUAL STATE AGENCY SPECIFICATIONS - QUANTITATIVE ASPECTS

This portion of the review on individual State agency specifications focuses on the quantitative (or numeric) aspects of the various State DOT specifications. It serves to illustrate the wide range of property values currently employed by the various State Agencies for the same, or similar applications as compared to the values recommended by AASHTO and/or Task Force #25. The applications selected for comparison are those mentioned earlier. The high, average and low values recorded in Tables 3-7 along with the high and low values from Table 1 are presented in Table 15 following:

Table 15 - Comparison of Minimum Property Values for Various Applications

	Range Between States			AASHTO/TF #25	
Application and Property	High	Average*	Low	High	Low
(a) Survivability/Separation					
Grab (lb)	270	138	90	270	90
Puncture (lb)	110	68	30	170+	30
Burst (lb/in.^{2})	430	238	140	430	145
Tear (lb)	75	49	25	75	30
(b) Drainage/Filtration					
Grab (lb)	200	89	25	180	80
Elongation (%)	95	27	10	20+	20+
Seam Strength (lb)	90	70	40	160	70
Puncture (lb)	120	48	25	80	25
Burst (lb/in.^{2})	400	152	100	290	130
Tear (lb)	50	38	25	50	25
Permeability (cm/sec)	8	.44	.01	.01+	.01+
UV (% strength retained)	90	65	35	100	70
(c) Silt Fence					
Grab (lb)	200	104	30	90+	90+
Elongation (%)	35	19	10	50	20
Permittivity (sec^{-1})	.2	.05	.005	.01+	.01+
UV (% strength retained)	90	71	35	100	70
(d) Control of Reflective Cracking					
Grab (lb)	180	102	78	80+	80+
Elongation (%)	150	52	15	50+	50+
Asphalt Retention (gal/yd^2)	.3	.22	.2	.20+	.20+
Melt Point (deg. F)	300	300	300	300	300

Table 15 - continued on next page

Table 15 - continued

(e) Permanent Erosion Control					
Grab (lb)	250	160	30	200	90
Elongation (%)	50	20	10		15+
Seam Strength (lb)	250	155	65	180	80
Puncture (lb)	120	70	40	80	40
Burst ($lb/in.^2$)	500	269	125	320	140
Tear (lb)	75	49	30	50	30
Permeability (cm/sec)	8	.49	0.001	.01+	.01+
UV (% strength retained)	90	76	70	100	70

*Average values are taken from the entire data set and are not merely the midrange of the high and low values given.

CHAPTER 6 - CONCLUSIONS

After review of the 50 States, the District of Columbia and Puerto Rico, we find that at least two areas of future development could have a meaningful and positive impact.

First, we find that each State essentially establishes its own format and terminology. This fact is evidenced through the examination of individual items covered in the different State specifications as seen in the information found in the tables presented earlier. It appears evident that if there is to be any sort of advancement in the proper use of geosynthetics within the transportation industry as a whole, a firm format and terminology guideline must be established. Many State specifications include relevant information, but the form in which they are presented makes it awkward at least and misleading at worst. When a specification is developed one must assume that the specification is consistent as well as accurate. Current specifications tend to repeat information which applies to each of the five major application areas examined. This problem could be alleviated by outlining the specification to cover each area once. This would not only make it easier to find the pertinent information, but also reduces the amount of paperwork needed to convey the same information.

The field of geosynthetic engineering is growing rapidly, but at the same time differing application terminology may prove to be a hindrance. In other words, the specification writer cannot assume that field personnel will understand the specifications without an adequate understanding of the terminology. All terms should be clarified to promote proper communication between the specifiers and those reading them (engineers, inspectors and contractors). Currently, States such as OR, WA, WI and PR have included a definition section to aid in this regard. Although each definition section is developed on need, we feel that it is essential that they become part of every specification.

The second area of concern is the random manner in which each State sets up its property matrix table of minimum test values. Despite the fact that many States are making an effort to follow the compiled efforts of Christopher, Holtz and DiMaggio*, information within their manual does not provide an answer to the problem of specification format. To remedy this situation it is advisable to examine specifications such as developed by the Washington State DOT which we feel are exemplary. For further development of format and style the good features found in the AK, CA, CO, FL, HI, ID, IL, ME, MT, NM, OR, PR, TX, UT, WA, WI, WY State DOT specifications should be considered and implemented by other states as appropriate. Having reviewed and commented upon the various features of the 46 specifications at hand, it was felt advisable to make definitive recommendations. To do this we have developed a sample specification (Appendix A) which has been culled from the positive

*Christopher, B.R., Holtz, R.D. and DiMaggio, J.A., Geotextile Engineering Manual, U.S. DOT, FHWA, Contract No. DTFH 61-80-C-00094, (latest version)

features of the various State specifications. This generic specification should be used as a guide upon which current specifications can be reexamined and updated as necessary.*

It is felt that efforts by FHWA in these areas could set the tone by which each State could compare its specifications with others, with the entire group of States and with the recommended specification that follows.

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*Please note that a possible option to this type of specification is to formulate an "approved bidders list". To do so specific geosynthetic materials would have to be prequalified by appropriate testing. Only those materials which are satisfactory could be used for a specific project. (See NY and NH for details of this type of approach.)

APPENDIX A

SAMPLE GENERIC GEOTEXTILE SPECIFICATIONS

APPENDIX A
Sample Generic Geotextile Specification

1.0 General Comments

- 1.1 Overview
- 1.2 Topic
- 1.3 Applications

2.0 Materials

- 2.1 General Requirements
- 2.2 Source Approval
- 2.3 Control Testing
- 2.4 Shipment
- 2.5 Storage
- 2.6 Certification and Guarantee
- 2.7 Property Basis

3.0 Construction Requirements

- 3.1 General Requirements
- 3.2 Specific Requirements
  - 3.2.1 Stabilization/Separation
  - 3.2.2 Reinforcement
  - 3.2.3 Filtration/Drainage
  - 3.2.4 Permanent Erosion Control
  - 3.2.5 Temporary Erosion Control (Silt Fences)
  - 3.2.6 Control of Reflective Cracking

4.0 Sampling and Testing

- 4.1 Sampling
- 4.2 Testing (Factory versus Field)
- 4.3 Acceptance Requirements

5.0 Miscellaneous Items

- 5.1 Method of Measurement
- 5.2 Basis of Payment
- 5.3 Other Geosynthetic Materials

6.0 Property Requirements

Table 1 - Minimum Required Property Values

7.0 Definitions

1.0 GENERAL COMMENTS

1.1 Overview

Geotextiles are defined by ASTM as "permeable textile-like materials used with soil, rock or any other geotechnical engineering-related material to enhance the performance or cost of a human-made product, structure or system." However, it is still very common to refer to them as "fabrics" which will be used interchangeably in this Specification. They are textiles in a traditional sense, but they are dissimilar in that they are composed of polymeric base elements (polypropylene, polyester, etc.) rather than natural base elements (silk, cotton, wool).

The base polymers, along with additives, fillers, etc., are made into fibers, among which are monofilament, multifilament, staple yarn, slit film or silt film yarn types. Fabrics are then formed where the choices are woven, nonwoven, or (occasionally) knit types. There are many styles of each, particularly among the nonwovens where bonding methods are needle-punched, melt-bonded (or heat-set) and resin-bonded. When placed in the ground these fabrics are properly called by their generic term "geotextiles." The final products have been utilized in over 80 specific application areas. Within the realm of transportation related activities there are six common application areas which are included in the following generic specification.

The prolific use of geotextiles in the above situations invariably requires the materials to perform at least one of the following five basic functions after installation.

- Separation
- Reinforcement
- Filtration
- Drainage
- Moisture barrier (when impregnated)

1.2 Topic

Geotextiles and related materials discussed in this Specification are all utilized in, or adjacent to, the subsoil environment. With few exceptions, the material will be covered with soil, rock, concrete or other construction material. As mentioned above, the base material will consist of a synthetic polymer. Thus the word "geosynthetic" describes the total area where the collected body of information can be located.

1.3 Applications

The location and intent of the geotextile must be clearly shown in the contract plans and documents. Geotextile applications described in this specification include; separation/stabilization, reinforcement, drainage/filtration, permanent erosion control, temporary erosion control (silt fence) and fabrics for the control of reflective cracking. The six application areas are defined as follows:

1. Separation/Soil Stabilization — Geotextiles used for soil separation and/or stabilization shall include applications in which the geotextile is used to prevent penetration of a fine subgrade soil into a coarser material by pumping. Simultaneously, the geotextile prevents the coarser material from intruding into the finer subgrade soil. Typical applications include the placement of geotextile between a highway base course or railroad ballast layer and the soil subgrade. Also included is the use of a geotextile layer between the subgrade and fill material for fills which are less than approximately 3 feet in **height.**

2. Reinforcement — For some applications using geotextiles and related materials, the primary function is one which develops global tension in the geosynthetic material. Thus reinforcement of walls, slopes, embankments on soft soils, etc., rely on the tensile strength of the geosynthetic material. Since these applications are often permanent and of a critical nature, they are very site specific in their design. Generally, they should be handled on a case-by-case basis and not be part of a standard specification. As such, they will usually form an addendum to a specific set of project plans and specification.

3. Filtration/Drainage — Drainage/filtration applications include edge of pavement drains, interceptor drains, wall drains, recharge basins, and relief wells. The geotextile must allow passage of water while retaining upstream soil. Furthermore, the geotextile must remain free of soil to the extent of not becoming permanently clogged. It must function for the proposed life of the drainage system it is meant to protect.

4. Permanent Erosion Control — Erosion control applications include cut and fill slope protection, protection of various drainage structures and ditches, wave protection for causeways and shoreline roadway embankments, and scour protection for structures such as bridge piers and abutments. The geotextile is usually placed beneath armor stone or under prefabricated block systems. Sometimes a protective cushion of sand is used above the geotextile. The geotextile must allow passage of water while retaining in-situ soil without clogging. The geotextile is a filter in the true sense of the word.

5. Temporary Erosion Control - Silt Fence — A geotextile silt fence is a temporary barrier used to retain sediment laden water, allow the soil particles to settle out, and then pass the relatively clear water through its voids. It creats a temporary retaining dam yet will remove suspended soil particles from the water passing through it. The use of silt fences during construction and post construction are an essential part of most erosion control and sedimentation plans.

6. Fabrics for the Control of Reflective Cracking — Fabrics are often used between pavement layers for the purpose of incorporating waterproofing

within the road system and possibly a stress relieving membrane within the pavement structure. This specification guide applies to fabric membranes used for full coverage of the pavement, or as strips over transverse and longitudinal pavement joints. It is not intended to describe membrane systems specifically designed for pavement joints and localized (spot) repairs nor is it intended to cover geomembranes as used in pond, canal or landfill liners.

2.0 MATERIALS

2.1 General Requirements

Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long chain polymers composed of at least 85% by weight of polypropylenes, polyethylenes, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages. These materials shall conform to the table of required properties found in Section 6.0.

Thread used for factory or field sewing shall be of contrasting color to the fabric and made of high strength polypropylene, polyester, or polyamide thread. The thread used to sew silt fence geotextiles and permanent erosion control geotextiles must be at least as ultraviolet resistant as the base fabric.

2.2 Source Approval

The contractor shall submit to the engineer a manufacturer's certificate of compliance which shall include the following information:

- Manufacturer's name, current address and telephone number
- Full product name by trademark and state number
- Geotextile polymer type(s), and
- Recommended geotextile use(s).

If more than one style, merge, or product code number (i.e., this number being representative of a geotextile whose properties are different from a geotextile with the same product name and different style, merge, or product code number) has been produced under the same product name, the style, merge or product code number of the geotextile to be approved must be specifically identified. If the geotextile has not been previously tested for source approval by the State, sample(s) of the geotextile shall be submitted to the State DOT testing laboratory or other approved laboratory as stipulated by the Agency. A minimum of 14 calendar days after the samples have arrived at the State DOT testing lab will be required for this testing. Source approval will be based on conformance to the applicable values from Table 1 of Section 6.0. Each sample shall have minimum dimensions of 1.5 yards by the full roll width of the geotextile. A minimum of 6 square yards of geotextile shall be submitted to the Engineer for testing. The geotextile machine direction shall be marked clearly on each sample submitted for testing. The machine direction is defined as the direction perpendicular to the axis of the geotextile roll.

The geotextile samples shall be cut from the geotextile roll with scissors, sharp knife, or other suitable method which produces a smooth geotextile edge and does not cause geotextile ripping or tearing. The samples shall not be taken from the outer wrap of the geotextile roll nor the inner warp next to the core.

If geotextile seams are to be sewn at the factory, at least one sewn sample, with a minimum of 2 yards of seam length per sample and with a minimum of 18 inches of geotextile width on each side of the seam shall also be submitted for each geotextile direction (i.e., machine or cross-machine direction) product to be sewn.

2.3 Control Testing

Samples will be randomly taken by the Engineer at the job site to confirm that the geotextile meets the property values specified. The Contractor shall provide a manufacturer's certificate of compliance to the Engineer which includes the following information about each geotextile roll to be used:

- Manufacturer's name and current address,
- Full product name by trademark or other description
- Style, merge, or product code number
- Geotextile roll number,
- Recommended geotextile use(s), and
- Certified property test results from the lot which the rolls shipped to the site were selected.

Approval will be based on testing of samples from each lot. A "lot" shall be defined for the purposes of this specification as all geotextile rolls within the consignment (i.e., all rolls sent to the project site) which were manufactured during a continuous period of production at the same manufacturing plant, have the same product name, and have the same style, merge, or product code number. Sampling shall be in accordance with Section 4.0 which is in approximate agreement with ASTM D4354. A minimum of 14 calendar days after the samples have arrived at the State DOT testing laboratory will be required for this testing. If the results of the testing show that a geotextile lot, as defined, does not meet the properties required for the specified use as indicated in Table 1, Section 6.0, the roll or rolls which were sampled will be rejected. Two additional rolls from the lot previously tested will then be selected at random by the Engineer for sampling and retesting. If the retesting shows that either or both rolls do not meet the required properties, the entire lot will be rejected. All geotextile which has defects, deterioration, or damage, as determined by the Engineer, will also be rejected. All rejected geotextile shall be replaced at no cost to the State.

2.4 Shipment

2.4.1 Packaging Requirements

The geotextile shall be packaged in rolls of the length and width specified on the plans, as directed by the Engineer or in the purchase order awarded by the State. The geotextile itself shall be uniformly wound onto suitable cylindrical forms or cores to aid in handling and unrolling. Each roll of fabric and the form or core upon which it is rolled shall be packaged individually in a suitable sheath, wrapper or container to protect the fabric from damage due to ultraviolet light and moisture during normal

storage and handling.

2.4.2 Labeling or Tagging

Each roll shall be identified by a tag or label securely affixed to the outside of the roll on one end. (See ASTM D-4873, "Guide for Identification and Handling of Geotextiles.") This tag or label must list the following required information:

a. A unique roll number, serially designated
b. Manufacturer's lot number or control numbers, if any
c. Name of fabric manufacturer
d. Date of manufacture
e. Brand name of the product
f. Manufacturer's style or catalog designation of the fabric, if any
g. Roll width in feet
h. Roll length in feet
i. Gross weight of entire package which is to include fabric, core, wrapping and sheath or container identification tag, etc.
j. Tare weight of core wrapping, sheath or container identification tag, etc.
k. Net weight of fabric alone

An example of the above type of information is given below:

a. Roll No. 31275
b. Lot 290 control 6740
c. ABC Fabrics Co., Inc.
d. Jan. 16, 1987
e. "ABC Fab"
f. "ABC-EC4"
g. Width 1.25 feet
h. Length 350 feet
i. Gross 147 pounds
j. Tare 18 pounds
k. Net Wt. 129 pounds

2.5 Storage

The geotextile shall be stored in accordance with ASTM D-4873. The geotextile shall be kept dry at all times and shall be stored off the ground. Under no circumstances, either during shipment or storage, shall the material be exposed to sunlight, or other forms of light which contains ultraviolet rays, for more than five calendar days.

2.6 Certification and Guarantee

2.6.1 Manufacturer's Certificate

The manufacturer shall file with the purchaser a certificate setting forth the name of the manufacturer, the chemical composition of the filaments or yarns, and other pertinent identification information so as to fully describe the geotextile. The certificate shall be attested to by a person having legal authority to bind the company. Either mismarketing or misrepresentation by the manufacturer shall be reason to discontinue acceptance under these specifications. Notice sent to the manufacturer by the purchaser regarding the discontinuance of acceptance will be considered to be notice to all wholesalers, jobbers, distributors, and other intermediaries handling the manufacturer's product.

2.6.2 Manufacturer's Guarantee

The manufacturer shall submit with or as part of the manufacturer's certificate a guarantee stating that the geotextile that is furnished meets the requirements of this specification. In addition, the manufacturer shall maintain test records of the production of this lot of material. These records shall be made available to the purchaser upon request.

2.7 Property Basis

Geotextile property values should be expressed in terms of "Minimum Average Roll Values" (MARV's) and should be compared directly to the corresponding specification values, also in MARV's. MARV's state that the minimum average property value of any roll within a shipment or lot of geotextile rolls meet or exceed the values required in the specification. The determination of the MARV value for a shipment or lot of geotextiles is illustrated in the following example.

Assume six (6) rolls of geotextiles were sampled to determine if a particular property met specification value. Eight (8) test specimens from each roll were laboratory evaluated with the following results. Using the average values of the tests from each roll, the MARV is seen to be 121. This value must meet, or exceed, the specification value.

Test	Roll No.					
No.	1	2	3	4	5	6
1	143	127	137	142	152	137
2	127	115	143	146	141	124
3	152	121	128	158	139	131
4	129	116	162	141	157	120
5	132	119	146	135	142	118
6	141	121	133	142	151	133
7	162	122	119	158	141	141
8	135	128	136	162	145	125
Average =	140	121	138	148	146	129

If the MARV does not meet the required specification value, the entire shipment or lot shall be resampled and the entire exercise repeated. If this second MARV value does not meet spec, the entire shipment or lot shall be rejected. If this second MARV value does meet the specification, the original roll with the low MARV value is the only roll to be rejected.

3.0 CONSTRUCTION REQUIREMENTS

3.1 General Requirements

The area to be covered by the geotextiles shall be graded to a smooth, uniform condition free from ruts, potholes, and protruding objects such as rocks or sticks. The geotextile shall be spread immediately ahead of the covering operation. No geotextiles, with the exception of geotextiles used for silt fences, shall be left exposed to sunlight during installation for a total of more than five calendar days. The geotextile shall be laid smooth without excessive wrinkles. Under no circumstances shall the geotextile be dragged through mud or over sharp objects which could damage the geotextile. The cover material shall be placed on the geotextile in such a manner that a minimum of 12 inches of material, depending on the survivability of the geotextile, will be between the vehicle or equipment tires, or tracks, and the geotextile at all times. If lift thicknesses are less than 12 inches, construction vehicles shall be limited in size and weight such that rutting in the initial lift above the geotextile is not greater than 3 inches deep, to prevent overstressing of the geotextile. Turning of vehicles on the first lift above the geotextile will not be permitted. Compaction of first lift above the geotextile shall be limited to routing of placement and spreading equipment only. No vibratory compaction will be allowed on the first lift.

Pegs, pins, or the manufacturer's recommended method shall be used as needed to hold the geotextile in place until the specified cover material is placed.

Should the geotextile be torn or punctured, or the overlaps or sewn joint disturbed, as evidenced by visible geotextile damage, subgrade pumping, intrusion, or roadbed distortion, the backfill around the damaged or displaced area shall be removed and the damaged area repaired or replaced by the Contractor at no cost to the State. The repair shall consist of a patch of the same type of geotextile used for the intended application, the patch shall overlap the existing geotextile a minimum of 2 feet from the edge of any part of the damaged area. Where geotextile seams are required to be sewn, any damaged sheets shall be repaired by sewing, unless otherwise indicated on the plans or special provisions, or as directed by the Engineer.

If the geotextile seams are to be sewn in the field or at the factory, the seams shall consist of two parallel rows of stitching. The two rows of stitching shall be 0.5 inch apart with a tolerance of ±0.25 inch and shall not cross, except the restitching. The stitching shall be a lock-type stitch. The minimum seam allowance, i.e., the minimum distance from the geotextile edge to the stitch line nearest to that edge, shall be 1.5 inches if a flat or prayer seam, i.e., Type SSa-2, is used. The minimum seam allowance for all other seam types shall be 1.0 inch. The seam, stitch type, and the equipment used to perform the stitching shall be as recommended by the manufacturer of the geotextile and as approved by the Engineer.

The seams shall be sewn in such a manner that the seam can be inspected readily by the Engineer or representative. The seam strength will be tested and shall meet the requirements stated in Table 1 of Section 6.0.

3.2 Specific Requirements

The construction requirements which follow shall apply in addition to the general construction requirements previously stated. They are listed in the order of their original presentation in Section 1.3.

3.2.1 Separation/Soil Stabilization

The geotextile shall either be overlapped a minimum of 2 feet at all longitudinal and transverse joints, or the geotextile shall be sewn together at all sheet intersections to form geotextile lengths and widths as required. The geotextile shall be chosen on the basis of minimum property requirements as specified in Table 1 of Section 6.0.

3.2.2 Reinforcement

Embankment and foundation reinforcement shall be constructed in accordance with the details shown on the construction plans. In general, the geotextile reinforcing layers shall be placed such that the geotextile machine direction shall be transverse to the embankment centerline. All adjacent geotextile sheets and adjoining ends shall be sewn, unless otherwise shown on the plans or in the special provisions. The geotextile shall be stretched so that all slack and wrinkles are eliminated. Construction vehicles shall be limited in size and weight such that rutting in the initial lift above the geotextile is no greater than 3 inches deep to prevent overstressing the geotextile. Embankment construction shall proceed in uniform lifts at all times to prevent overstressing the geotextile and causing differential ground movements. Use of geotextiles in this manner and subsequent specification development is site and project specific.

3.2.3 Filtration/Drainage

The geotextile shall either be overlapped a minimum of 1 foot at all longitudinal and transverse joints, or the geotextile joints shall be sewn. In those cases where the trench width is less than 1 foot, the minimum overlap shall be the trench width. Dependent upon application, the geotextile used shall be chosen as specified in Table 1 of Section 6.0.

3.2.4 Permanent Erosion Control

Unless otherwise specified in the construction plans, the geotextile shall either be overlapped a minimum of 2 feet at all longitudinal and transverse joints, or the geotextile shall be sewn together at all joints at the point of manufacture to form geotextile widths as required. If overlapped, the geotextile shall be placed so that the upstream roll of geotextile will overlap the next downstream roll. Where placed on slopes, each roll shall overlap the next downhill roll.

The geotextile shall be keyed at the toe and the top of the slope as shown in the construction plans. The geotextile shall be secured to the slope, so as to make intimate contact with it. It shall not be so tight, however, as to cause tearing when the riprap is placed on the geotextile. The geotextile shall not be keyed at the top of the slope until the riprap is in place to the top of the slope. Placement of stone aggregate, rock riprap, or prefabricated armor systems, on the geotextile shall start at the toe of the slope and proceed upwards.

All voids in the riprap face that allow the geotextile to be visible shall be backfilled with quarry spalls or other small stones, as designated by the Engineer, so that the geotextile is completely covered. When a sand or stone aggregate cushion between the geotextile and the riprap is required, it shall have a minimum thickness of 6 inches.

The geotextile survivability requirements and, hence, minimum property values for permanent erosion control are determined based on slope height, slope angle, presence of aggregate cushion, stone size, and drop height. Geotextiles meeting the requirements for low survivability geotextile, as shown in Table 1 of this section, shall be used if the geotextile is placed on slopes flatter than 2:1 with a maximum slope height of 10 feet, or on slopes flatter than 2.5:1 with a slope height greater than 10 feet. Geotextiles placed on slopes which do not meet the above requirements must meet the requirements shown in Table 1 for high survivability geotextiles.

As seen in Table 1, geotextile survivability is defined for various combinations of stone size, drop height, and cushion thickness. Under no circumstances shall the combinations of stone size, cushion thickness, and drop height listed be exceeded, unless the Contractor can demonstrate, to the satisfaction of the Engineer, that the geotextile will not be damaged by exceeding these combinations. Allowable combinations of stone size, aggregate cushion thickness, and drop height are as follows. In most cases the required property values for geotextiles used in this application will be separated into two classes; one reflecting low survivability, the other reflecting high survivability.

Table 1 - Survivability Table for Permanent Erosion Control Geotextiles

Maximum Stone Size	Geotextile Survivability Designation	
	Low Survivability	High Survivability
300 lbs.	No cushion, with max. 1 ft. drop	No cushion, with max. 3 ft. drop
500 lbs.	No cushion, with no free-fall allowed	No cushion, with max. 1 ft. drop
2,000 lbs.	12" cushion, with max. 1 ft. drop	No cushion, with no free-fall allowed
Greater than 2,000 lbs.	12" cushion, with no free-fall allowed	12" cushion with max. 1 ft. drop

Grading of slopes after placement of the riprap will not be allowed if grading results in stone movement directly on the geotextile. Under no circumstances shall stones weighing more than 100 pounds be allowed to roll down the slope. If the geotextile is placed on slopes steeper than 2:1, the stones shall be placed on the slope without free-fall for both low survivability and high survivability geotextiles.

3.2.5 Temporary Erosion Control (Silt Fences)

The geotextile shall be attached on the up-slope side of the posts and support system with staples, wire, or in accordance with the manufacturer's recommendations. Silt fence backup support for the geotextile in the form of a wire or plastic grid is optional, depending on the properties of the geotextile selected for use. As indicated in Table 1 in Section 6.0 two classes are distinguished. If wire or plastic backup grid is used, the grid material shall be fastened securely to the up-slope side of the posts with the geotextile being upslope of the grid backup support.

The geotextile shall be sewn together at all edges at the point of manufacture, or at an approved location as determined by the Engineer, to form geotextile lengths and widths as required. Alternatively, a geotextile seam may be formed by folding the geotextile from each geotextile section over on itself several times and firmly attaching the folded seam to the fence post, provided that the Contractor can demonstrate, to the satisfaction of the Engineer, that the folded geotextile seam can withstand the expected sediment loading.

The geotextile at the bottom of the fence shall be buried in a trench to a minimum depth of 6 inches below the ground surface. The trench shall be backfilled and the soil tamped in place over the buried portion of the geotextile as shown on the Plans such that no flow can pass beneath the fence nor scour occur in this area. When wire or polymeric backup support mesh is required, the wire or polymeric mesh shall extend into the trench a minimum of 3 inches. The fence posts shall be placed or driven a minimum of 18 inches into the ground. Where an 18 inch depth is impossible to obtain, the posts shall be adequately secured by bracing or guying to prevent overturning of the fence due to sediment loading, as approved by the Engineer.

Either wood or steel posts shall be used. Wood posts shall have minimum dimensions of 1 inch by 1 inch by the minimum length shown on the Plans, and shall be free of defects such as knots, splits, or gouges. Steel posts shall consist of either size No. 6 rebar or larger, or shall consist of ASTM A 120 steel pipe with a minimum diameter of 3/4 inch. The spacing of the support posts shall be as directed on the Plans or as recommended by the manufacturer with approval of the Engineer.

Fence backup support, if used, shall consist of 14 gage steel wire with a mesh spacing of 6 inches, or a prefabricated polymeric mesh (for example, a biaxial geogrid) with support capabilities equivalent to the wire fencing. The polymeric mesh must be as resistant to ultraviolet radiation as the geotextile it supports.

Sediment deposits which accumulate over time behind the silt fence shall either be removed when the deposit reaches approximately 1/2 the height of the silt fence, or a second silt fence upstream of the first shall be installed, as determined by the Engineer.

3.2.6 Control of Reflective Cracking

1. Surface Preparation: The surface on which the fabric is to be placed shall be prepared by using the following methods, as directed by the Engineer. It is assumed that soil foundation, stone base course, and large pavement failures have not occurred or have been suitably repaired prior to the placement of the paving fabric focused upon in this section.

   a. Remove all loose materials on the pavement surface by power wire brooming.
   b. Use air or water pressure jet to clean the cracks and construction expansion joints.
   c. Use hand scraping to remove excess asphaltic materials and other foreign materials.
   d. All cracks larger than 1/4 inch in width shall be filled with an asphalt emulsion and sand slurry as directed by the Engineer. The slurry proportions will be set by the Engineer and Regional Materials Laboratory. All excess slurry mixture shall be removed.

2. Application of Sealant: The asphaltic sealant must be uniformly spray applied at 0.20 to 0.35 gallons per square yard depending upon the condition of the pavement and the type of geotextile. The exact amount and type will be recommended by the contractor and/or manufacturer and approved by the Engineer. Temperature of the asphaltic sealant can vary between 295°F. min. and 325°F. max. Application of the asphaltic sealant will be by distributor equipment. The distributor must be properly metered and capable of spraying the asphalt at the prescribed uniform application rate. The distributor shall meet all requirements set forth under applicable State specifications.

   Asphaltic material shall not be applied on a wet or damp pavement surface or when the ambient air temperature is below 45°F or when other conditions would prevent the proper application of the sealant.

3. Fabric Laydown Equipment: Mechanical laydown equipment with a proven history of successful fabric laydown in this type of application must be capable of handling full rolls of fabric and shall be capable of laying the fabric smoothly, without wrinkles and/or folds.

4. Fabric Placement: The fabric shall be placed directly on top of the asphaltic sealant (tack coat) with a minimum of wrinkles prior to the time the sealant has cooled and lost its tackiness. The fabric shall be unrolled and placed in accordance with the manufacturers recommendations. Wrinkles which result

in folds when flattened shall be slit and laid flat in the direction of paving as directed by the Engineer. Fabric overlapping shall be a minimum of 3 inches at all fabric joints. Transverse joints shall be shingled in the direction of paving to prevent fabric pick-up by the paver. At all fabric edges, 0.20 gallons per square yard of additional asphaltic sealant shall be applied beneath the joint. Under no case shall wheeled traffic other than the paving operation itself, be ever allowed on the exposed fabric.

5. Bituminous Surface Course Overlay: Placement of bituminous surface course must closely follow the fabric laydown as directed by the Engineer. The Contractor must schedule the fabric laydown and bituminous surface course paving such that at the completion of either "end of day" operations or weather stoppage, no exposed fabric is left uncovered. This procedure is to ensure that no fabric is left exposed overnight or to inclement weather. In the advent that the asphalt sealant bleeds through the fabric before the placement of the overlay, sand or bituminous surface course will be evenly spread over the affected area to prevent fabric pick-up by construction equipment. Turning and/or pivoting of the paver or other construction equipment on the fabric before placement of the overlay must be gradual to prevent any movement and/or damage to the fabric.

4.0 SAMPLING AND TESTING

4.1 Sampling

All geotextiles shall be sampled in accordance with ASTM's D4354 standard practice entitled "Standard Practice for Sampling of Geotextiles for Testing." The production unit used for sampling shall be a roll.

4.1.1 Control Sampling

The Engineer or representative should randomly select and obtain geotextile samples as soon as the geotextile rolls arrive at the site. The minimum sample size from a roll should be 1.5 yards by the full roll width. The sample should not be taken from the outer wrap of the roll nor the inner wrap of the core (i.e., do not take the sample from the geotextile at the very ends of the roll). The samples should be taken from the minimum number of rolls, based on the size of the lot, recommended in ASTM's D4354, entitled "Standard Practice for Sampling of Geotextiles for Testing." Please note that the samples required for control testing are to be taken at the job site, whereas the samples to be taken for the purpose of source approval, as required in Section 2.2, are taken before the fabric is shipped to the job site.

4.1.2 Selection of Specimens from Samples for Source Approval and Control Testing

As discussed above in "Control Sampling" and in Section 2.2 under "Source Approval," a minimum sample size of 1.5 yards by the full fabric roll width in size are needed from each roll selected to perform the required testing. No less than three specimens for a particular test (generally three to ten specimens are required for each particular test) should be taken from any individual sample. Of course, specimens for different types of tests can be, and should be, taken from the same fabric sample. Test specimens taken across the roll can be obtained by folding the fabric two or three times and stamping out sections, with a cutting die and press, to the required dimensions. Alternatively, specimens can be marked out on the fabric and cut with scissors or other cutting tools. Because, in many cases, specimens can easily unravel, special handling procedures are required. Either the specimen can be overcut and raveled down to the appropriate test specimen dimension, cut with a hot knife, or glued along the cutting edge with a very weak rubber cement. In any case, care must be taken in the cutting procedures such that they do not affect test results. No specimens should be taken nearer than 2 inches from the selvage edge of the roll. If at all possible, test specimens should be randomly selected across the width of the roll such that different machine direction yarns are contained in each test specimen. Figure 1 shows an example of test specimen selection. Observance of these procedures will provide a representative cross section of fabric production.

The number of specimens required for each test will likely be the minimum required by each test method for source approval testing, as the coefficient of variation, v, will likely be unknown. The coefficient of variation obtained from testing for source

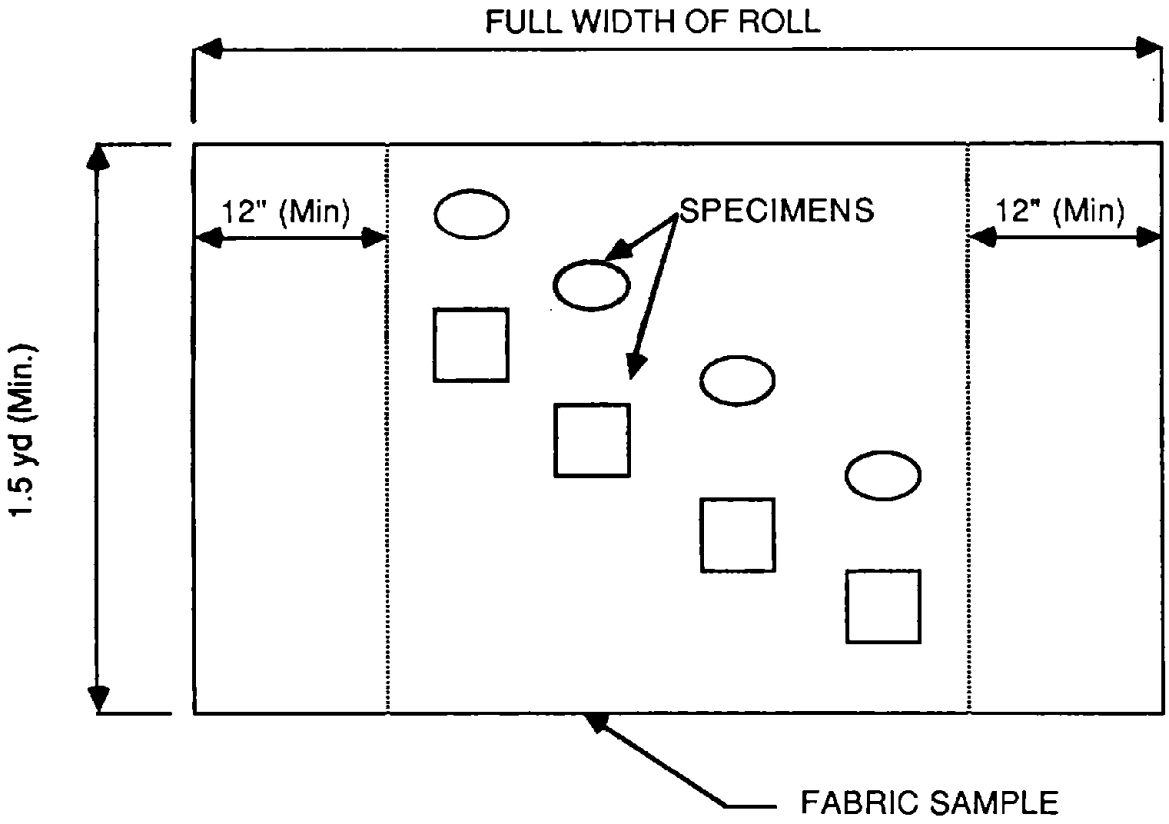

Figure 1 - Test Specimen Selection

approval and/or from previous control sample testing can be used to determine the number of specimens required for control sample testing. Knowing this coefficient of variation will reduce the number of specimens required for a particular test significantly.

The average value of all of the specimens tested for each fabric property on each roll sampled shall be used to determine the "minimum average roll value" and to see if the fabric has met the criteria set forth in Table 1 of Section 6.0, recall Section 2.7.

4.2 Testing (Factory and Field)

Tests shall be performed on sampled geotextiles to determine conformance with all geotextile properties specified herein for the intended application(s). All geotextile property requirements are minimum average roll values. The tensile strengths values shall be determined in both machine and cross-machine directions.

Source (factory) testing submittal requirements are found in Section 2.2. Control (field) testing submittal requirements are found in Section 2.3.

4.3 Acceptance Requirements

Acceptance/rejection of geotextiles shall be determined in accordance with ASTM D4759 Standard Practice for determining the specification conformance of geosynthetics.

5.0 MISCELLANEOUS ITEMS

5.1 Method of Measurement

In each of the application areas to be described (and others not specifically mentioned as well), the measurement for payment excludes the fabric used for overlapping as well as fabric used for seam overlaps. Thus only the surface area of soil covered is included in the measurement.

5.1.1 Separation/Stabilization

Separation/stabilization geotextiles will be measured to the nearest square yard of surface area actually covered in accordance with the plans or as required by the Engineer.

5.1.2 Reinforcement

Reinforcement geotextiles will be measured to the nearest square yard of surface area actually covered in accordance with the Plans or as required by the Engineer.

5.1.3 Filtration/Drainage

(a) The geotextile shall be measured by the number of square yards computed from the payment lines shown on the plans or from payment lines established in writing by the Engineer.
(b) Excavation, backfill, bedding and cover material are separate pay items.

5.1.4 Permanent Erosion Control

(a) The geotextile shall be measured by the number of square yards computed from the payment lines shown on the plans or from payment lines established in writing by the Engineer. This shall include geotextiles used in crest and toe of slope treatments.
(b) Slope preparation, excavation and backfill, bedding, and cover material are separate pay items.

5.1.5 Temporary Erosion Control (Silt Fence)

(a) Temporary silt fence will be measured in linear feet, complete in place. The height of the silt fence shall be in accordance with the construction planes.
(b) Removed sediment will be measured by the cubic yard.

5.1.6 Control of Reflective Cracking

(a) The paving fabric will be measured by the square yard. This excludes seam overlays.
(b) Asphalt sealant for the paving fabric will be measured by the gallon.

5.2 Basis of Payment

5.2.1 Separation/Stabilization

(a) The accepted pay quantities for geotextiles will be paid for at the contract price per square yard in place.
(b) Payment will be made under:

Pay Item	Pay Unit
Stabilization/Separation Geotextile	Square Yard

5.2.2 Reinforcement

(a) The accepted pay quantities for geotextiles will be paid for at the contract price per square yard in place.
(b) Payment will be made under:

Pay Item	Pay Unit
Reinforcement Geotextile	Square Yard

5.2.3 Filtration/Drainage

(a) The accepted quantities of geotextiles shall be paid for at the contract unit price per square yard in place.
(b) Payment will be made under:

Pay Item	Pay Unit
Filtration/Drainage Geotextile	Square Yard

5.2.4 Permanent Erosion Control

(a) The accepted quantities of geotextile shall be paid for per square yard in place.
(b) Payment will be made under:

Payment Item	Pay Unit
Erosion Control Geotextile	Square Yard

5.2.5 Temporary Erosion Control (Silt Fence)

(a) Temporary silt fence will be paid for per linear foot which shall be full compensation for completing the work specified. Such payment shall be full compensation of furnishing all materials, erecting, maintaining, and removing the fence.
(b) Removing of accumulated sediments shall be paid for by cubic yards.
(c) Dressing and grassing will be paid for by acre.
(d) Payment will be made under:

Pay Item	Pay Unit
Silt Fence	Linear Foot
Removing Sediments	Cubic Yards
Grassing	Acre

5.2.6 Control of Reflective Cracking

(a) The accepted quantities of paving fabric will be paid for at the contract unit price per square yard in place.
(b) The accepted quantities of asphalt sealant for paving fabric will be paid for at the contract unit price per gallon complete in place.
(c) Payment will be made under:

Pay Item	Pay Unit
Paving Fabric	Square Yard
Asphalt Sealant for Paving Fabric	Gallon

5.3 Other Geosynthetic Materials

Although this generic specification is established to aid in the efficient use of geotextiles, there are other geosynthetics which deserve consideration. The other geosynthetics developed to date are defined as follows.

Geogrid — A gridlike polymeric material consisting of intersecting ribs joined at their junctions used for reinforcement with foundation, soil, rock, earth, and any other geotechnical engineering-related material as an integral part of a human-made project structure or system.

Geomembrane — An essentially impermeable membrane used as a vapor or moisture barrier with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.

Geonet — A netlike polymeric material formed from intersecting ribs integrally joined at the junctions used for liquid drainage with foundation, soil, rock, earth, or any other geotechnical related material as an integral part of a human-made project, structure or system.

Geocomposite — A manufactured material using geotextiles, geogrids, geonets and/or geomembranes in laminated or composite form.

Geocell — A three-dimensional geosynthetic structure filled with soil, thereby forming a mattress for increased bearing capacity and trafficking on loose or compressible subsoils as well as other applications.

6.0 Test Property Requirements

The minimum average roll value (MARV) for every test property listed in Table 1 must be met for the particular application under consideration. All values listed are minimum (rather than maximum) unless specifically noted or unless stipulated on the construction plans or by the Engineer.

Authors' Footnote:

Since most State DOTs have had considerable experience in the use of different geotextiles, the required test property values that are important and their respective magnitudes vary greatly. This is due to a number of factors, many of which are site specific. For example, the following items vary considerably;

- seasonal moisture conditions,
- seasonal temperature variations,
- predominate existence of rock versus soil,
- predominate existence of coarse-grained versus fine-grained soils,
- urban versus rural settings, e.g., congestion,
- criticality of a specific application, and
- degree of conservativeness of the Agency.

Thus it is not possible to list numeric values of test properties in a general sense. Table 1 following, however, does give the format in which many existing specifications are framed. Table 1 is written with application areas conforming to the text of this generic specification. If additional applications are considered they can be added in a similar manner. It should be obvious that the recommendations of AASHTO and Task Force #25 should be considered. They are included for reference in Appendix A and Appendix B, respectively.

Table 1. Minimum Required Property Values (MARV) by Application Area

Geotextile Text Property	Test Method	APPLICATION AREA							
					Permanent Erosion Control		Temporary Erosion Control		
		Stabilization/ Separation	Reinforcement	Filtration/ Drainage	Class A (low surv.)	Class B (high surv.)	Class A (with backup)	Class B (without backup)	Control of Reflective Cracking, i.e., Paving Fabric
1. Tensile Strength									
Grab (lbs)	ASTM D-4632								
Wide Width (lbs/in)	ASTM D-4595								
2. Tensile Elongation									
Grab (%)	ASTM D-4632								
Wide Width (%)	ASTM D-4595								
3. Seam Breaking Strength (lbs)	ASTM D-4884								
4. Burst Strength ($lb/in.^2$)	ASTM D-3786								
5. Puncture (lbs)	ASTM D-3787								
6. Trapezoidal Tear Strength (lbs)	ASTM D-4533		VALUES TO BE DETERMINED BY INDIVIDUAL STATE AGENCIES. SEE TF #25 and AASHTO GUIDELINES.						
7. Abrasion Resistance (lbs)	ASTM D-4886								
8. Percent Open Area (POA) (woven geotextiles)	U. S. Corps of Engineers CW-02215								
9. Apparent Opening Size (AOS) (sieve size)	ASTM D-4751								
10. Permittivity (sec^{-1})	ASTM D-4491								
11. Slurry Flow Rate gal/min/ft	VA DOT VTM-51								
12. Retention Efficiency (%)	VA DOT VTM-51								
13. Temperature Stability	ASTM D-4594								
14. Asphalt Retention (gal/yd^2)	TX DOT 3002								
15. UV Resistance (% strength retained)	ASTM D-4355								

7.0 Definitions

Actinic degradation — The strength loss of fibers and fabrics due to exposure to sunlight or an accelerated weathering light source.

Arching — The formation of soil particles upstream of a geotextile where the particles arch (or bridge) over the fabrics' voids.

Basis weight* — A deprecated term for *mass per unit area.*

Blinding — The condition in which soil particles block the voids at the surface of a geotextile, thereby reducing the hydraulic conductivity of the geotextile.

Blocking — A synonym for blinding.

Bonding — The process of combining fibers, filaments, or films into sheets, webs, or bats by means of mechanical, thermal, or chemical binding.

Clogging — The movement by mechanical action or hydraulic flow of soil particles into the voids of a fabric and retention therein, thereby reducing the hydraulic conductivity of a geotextile.

Composite — *See* Fabric, composite.

Cross-plane — The direction of a geosynthetic which is perpendicular to the plane of its manufactured direction. Referred to in hydraulic situations.

Deformation — The change in length of a geosynthetic under load from its original manufactured dimensions.

Denier — The weight in grams of 9000 m of yarn.

Density* — The mass per unit volume.

Direction, cross-machine — The direction perpendicular to the long, machine or manufactured direction.

Direction, machine — In textiles, the direction in a machine-made fabric parallel to the direction of movement the fabric followed in the manufacturing machine (synonym, lengthwise, or long direction).

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Downstream — The direction of the opposite side of a geotextile from which water is moving.

Elongation — The increase in length produced in the gage length of the test specimen by a tensile load.

Elongation at break — The percent elongation corresponding to the maximum load.

Elongation, percent — For geosynthetics, the increase in length of a specimen expressed as a percentage of the original gage length (i.e., engineering strain).

Fabric, composite — A textile structure produced by combining nonwoven, woven, or knit manufacturing methods.

Fabric, knit — A textile structure produced by interlooping one or more ends of yarn or comparable material.

Fabric, nonwoven — For geotextiles, a planar and essentially random textile structure produced by bonding, interlocking of fibers, or both, accomplished by mechanical, chemical, thermal, or solvent means, and combinations thereof.

Fabric, woven — A planar textile structure produced by interlacing two or more sets of elements, such as yarns, fibers, roving, or filaments, where the elements pass each other, *usually* at right angles, and one set of elements are parallel to the fabric axis.

Filament yarn — The yarn made from continuous filament fibers.

Fill — A deprecated term for *filling*.

Filling — The yarn running from selvage to selvage at right angles to the warp in a woven fabric.

Filling direction — *See* Direction, cross-machine. *Note:* For use with woven fabrics only.

Filter cake — The soil structure developed upstream of a geotextile by separating the suspended soil from water as the mixture attempts to pass through a soil-fabric system.

Filter cloth — A deprecated term for *geotextile*.

Geocell — A three-dimensional structure filled with soil, thereby forming a mattress for increased bearing capacity and maneuverability on loose or compressible subsoils.

Geocomposite — A manufactured material using geotextiles, geogrids, geonets, geomembranes, and/or other polymeric or natural layers in laminated or composite form.

Geogrid — A deformed or nondeformed gridlike polymeric material formed by intersecting ribs joined at the junctions used for reinforcement with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project structure or system.

Geomembrane — An essentially impermeable membrane used as a liquid or vapor barrier with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.

Geonet — A netlike polymeric material formed from intersecting ribs integrally joined at the junctions used for drainage with foundation, soil, rock, earth, or any other geotechnical-related material as an integral part of a human-made project, structure, or system.

Geosynthetic engineering — The application of scientific methods and engineering principles to employ synthetic materials to the solution of geotechnical engineering problems, see geotechnical engineering.

Geosynthetics — The generic classification of all synthetic materials used in geotechnical engineering applications; it includes geotextiles, geogrids, geonets, geomembranes, and geocomposites.

Geotechnical engineering* — The engineering application of geotechnics.

Geotechnics* — The application of scientific methods and engineering principles to the acquisition, interpretation, and use of knowledge of materials of the earth's crust to the solution of engineering problems; it embraces the field of soil mechanics, rock mechanics, and many of the engineering aspects of geology, geophysics, hydrology, and related sciences.

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

Gradient — The degree of slope or a rate of change of a parameter measured over distance.

Heat bonded — *See* Melt-bonded.

Hydrophilic — A material's attraction to water.

Hydrophobic — A material's repulsion of water.

In-plane — The direction of a geosynthetic that is parallel to its long, manufactured, or machine direction. Referred to in hydraulic situations.

Knit — *See* Fabric, knit.

Mass per unit area — The proper term to represent the amount of material per unit area (units are oz./yd.^{2} or g/m^2). Often incorrectly called "weight" or "basis weight."

Melt Bonded — Thermally bonded by melting the fibers to form weld points.

Modulus of elasticity — The initial linear portion of the stress-versus-strain test of a geosynthetic during its evaluation in a tensile strength test. (Units are lb./in.^{2}, kPa, lb./in., or kN/m).

Needle-punched — Mechanically entangled by needling with barbed needles.

Nonwoven — *See* Fabric, nonwoven.

Normal direction* — For geotextiles, the direction perpendicular to the plane of a geotextile.

Permeability — A generic term for the property that reflects the ability of a material (in this case a geotextile) to conduct a fluid. Properly called *hydraulic conductivity.*

Permittivity — For a geotextile, the volumetric flow rate of water per unit cross-section area, per unit head, under laminar flow conditions, in the normal direction through the fabric.

pH — A measure of the acidity or alkalinity of a material, liquid, or solid. pH is represented on a scale of 0 to 14; 7 represents a neutral state; 0 represents the most acid, and 14 the most alkaline.

Resin-bonded — The joining of fibers at their intersection points by resin in the formation of a nonwoven geotextile or geocomposite.

Siphoning — The transferring of a liquid to a lower level over an intermediate higher elevation than both of the endpoints, which can be achieved by saturated geotextiles in planar flow.

Staple — Short fibers in the range 0.5 to 3.0 in. (1 cm to 8 cm) long.

Staple yarn — Yarn made from staple fibers.

Tenacity — The fiber strength on a grams per denier basis.

Tex — Denier multiplied by 9 and is the weight in grams of 1000 m of yarn.

Transmissivity — For a geotextile, the volumetric flow rate per unit thickness under laminar flow conditions, within the in-plane direction of the fabric.

Transverse direction — A deprecated term for *cross-machine direction.*

Ultraviolet degradation — The breakdown of polymeric structure when exposed to natural light.

Upstream — The direction from which flowing liquid approaches a filter or drain.

Voids — The open spaces in a geosynthetic material through which flow can occur.

Water table — (1) The upper limit of the part of the soil or underlying rock material that is wholly saturated with water [EPA, 1972]. (2) The upper surface of the zone of saturation in groundwaters in which the hydrostatic pressure is equal to atmospheric pressure [Fed. Regist., 1978].

Weft — A deprecated term for cross-machine direction.

Width — For a geotextile, the cross-direction edge-to-edge measurement of a fabric in a relaxed condition on a flat surface.

Woof — A deprecated term for *cross-machine direction.*

Woven — *See* Fabric, woven.

Woven, monofilament — A woven fabric produced with monofilament yarns.

Woven, multifilament — A woven fabric produced with multifilament yarns.

Woven, slit-film — A woven fabric produced with yarns produced from slit film.

Woven, split-film — *See* Woven, slit-film.

Yarn* — A generic term for continuous strands of textile fibers or filaments in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric. *Yarn* may refer to (1) a number of fibers twisted together, (2) a number of filaments laid together without twist (a zero-twist yarn), (3) a number of filaments laid together with more or less twist, or (4) a single filament with or without twist (a monofilament).

APPENDIX B

AASHTO GUIDELINES

APPENDIX B
Standard Specifications for
Geotextiles Used for Subsurface Drainage Purposes
AASHTO Designation: M288-84

1. SCOPE

1.1 This specification covers woven or nonwoven geotextiles fabrics when used for subsurface drainage purposes.

2. APPLICABLE STANDARDS

2.1 *ASTM Standards*[1]
D1682 Breaking Load and Elongation of Textile Fabrics
D 751 Coated Fabrics Testing
D 1117 Testing Nonwoven Fabrics
D 2263 Testing Woven Fabrics
D 1777 Measuring Thickness of Textile Materials

2.2 Corps of Engineers Standards:[2]
C. O. E., CW-02215 Equivalent Opening Size

[1]Can be obtained from ASTM, 1916 Race Street, Philadelphia, PA 19103

[2]Can be obtained from C.O.E., Office of the Chief of Engineers, Department of the Army, Washington, DC 20314.

3. PHYSICAL AND CHEMICAL REQUIREMENTS

3.1 The geotextile fabric shall be a woven or nonwoven fabric consisting only of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. The fabric shall be inert to commonly encountered chemicals and conform to the requirements shown in Table 1.

Table 1 Physical Requirements for Geotextiles

Test Method	Minimum Permissible Value
ASTM D 1682 (Tensile Strength), lbs	90
ASTM D 1682 (Tensile Elongation), pct	20
ASTM D 751 (Burst Strength), psi	140
ASTM 1117 (Trapezoid Tear Strength), lbs	45
CW-02215 (Puncture Strength), lbs	45
CW-02215 (E.O.S) (U. S. Standard Sieve Size)[a]	40-100
Attached (Coefficient of Permeability), cm/sec[b]	0.01
Attached (Flow Rate), gal/min/ft^2	40

[a]To be determined for specific site conditions. E.O.S. is difficult to determine for nonwoven and may be viewed by the purchaser.

[b]$k_{Fabric} > 10\ k_{Soil}$

4. QUALITY CONTROL

4.1 The geotextile manufacturer is responsible for establishing and maintaining a quality control program so as to assure compliance with the requirements of this specification.

5. SAMPLING AND TESTING

5.1 The product shall be subject to sampling the testing. The sampling shall be by random basis per manufacturer's lot. Each lot sampled shall provide a sample of three (3) square yards size and all tests will be run in triplicate.

6. CERTIFICATION

6.1 *Manufacturer's Certificate.* The manufacturer shall file with the purchaser a certificate setting forth the name of the manufacturer, the chemical composition of the filaments or yarns, and other pertinent information so as to fully describe the geotextile. The certificate shall be attested to by a person having legal authority to bind the company. Either mismarking or misrepresentation by the manufacturer shall be reason to discontinue acceptance under these specifications. Notice sent to the manufacturer by the purchaser regarding the discontinuance of acceptance will be considered to be notice to all wholesalers, jobbers, distributors, agents and other intermediaries handling the manufacturer's product.

6.1 *Manufacturer's Guarantee.* The manufacturer shall submit with the certificate a guarantee stating that the geotextile that is furnished meets the requirements of this specification. In addition, the manufacturer shall maintain test records as required by this specification. These records shall be made available to the purchaser upon request.

7. SHIPMENT AND STORAGE

During periods of shipment and storage, the fabric shall be protected from direct sunlight, ultraviolet rays, temperatures greater than 140 deg. F., mud, dirt, dust, and debris. To the extent possible, the fabric shall be maintained wrapped in a heavy-duty protective covering. Each shipping document shall include a notation certifying that the geotextile is in accordance with the manufacturer's certificate and guarantee previously filed with the purchaser.

FALLING-HEAD WATER PERMEABILITY OF FILTER FABRIC: DETERMINATION OF PERMEABILITY COEFFICIENT AND FLOW RATE AT A GIVEN CHANGE IN WATER HEAD

X1.1 SCOPE

X1.1.1 This procedure provides for (1) determination of coefficient of water permeability for filter fabrics ad (2) flow rate of water through a fabric determined by a falling head permeameter test.

X1.2 APPLICABLE DOCUMENTS

X1.2.1 *ASTM Standards:*
D1777 Measuring Thickness of Textile Materials

X1.3 APPARATUS

X1.3.1 Falling-head fabric permeameter [2-in. (50.8 mm) diameter Plexiglas standpipe with a cross-sectional area of 3.14 in.^{2} (20.27 cm^2) above a fabric sample placed over a 1-in. (25.4 mm) orifice; the cross-sectional area of flow through the test fabric is 0.79 in.^{2} (5.07 cm^2)] (Figure 1).

X1.3.2 Water Supply.

X1.3.3 Fabric thickness gauge that meets the requirements outlined in ASTM D1777 [2.819 in (71.60 mm) diameter pressure foot weighing 16 ozs (454 gms)].

X1.3.4 Celsium thermometer.

X1.3.5 Stopwatch.

X1.3.6 Rubber gaskets to fit flanges in falling-head fabric permeameter.

X1.4 SAMPLE PREPARATION

X1.4.1 Cut a circular fabric sample to fit flanges of permeameter [14.7 in. (119 mm) diameter].

X1.4.2 Measure thickness of fabric sample according to the procedure outlined in ASTM D1777, record on data sheet (Attachment 1).

X1.4.3 Place fabric layer on bottom flange of permeameter, attach a rubber gasket of appropriate thickness around fabric.

X1.4.4 Place top section of permeameter over fabric and gasket; fasten flanges securely with clamps or bolts.

X1.4.5 Fill standpipe with water.

X1.4.6 Open water release valve for a few seconds to saturate filter fabric; close valve.

X1.5 TEST PROCEDURE

X1.5.1 The object of this procedure is to determine the time required for water to travel through the fabric filter as the height of the water column is reduced from h_0 to h_1.

X1.5.2 The values recommended for h_0 and h_1 are 20 cm and 20 cm respectively. This low head level is suggested to provide flow within or close to the laminar range.

X1.5.3 An elapse time (t) for the (h_0-h_1) condition should be determined according to the following procedure.

X1.5.3.1 Raise water level in standpipe until it reaches the desired starting height of h_0 (20 cm). Use pipette for fine adjustment of pressure head level to exactly h_0.

X1.5.3.2 Record temperature of water in system.

X1.5.3.3 Open water release valve and start stopwatch simultaneously.

X1.5.3.4 Stop stopwatch when water level reaches the desired lower level of h_1 (10 cm).

X1.5.3.5 Record time (t) on data sheet.

X1.5.3.6 Repeat above procedure four times.

X.1.6 CALCULATIONS

X1.6.1 Permeability Coefficient:

The coefficient of permeability, k, is computed using the following equation:

$$k = \left(\frac{aL}{At}\right)\left(\ln\frac{h_0}{h_1}\right) \qquad \text{(Eq. 1.)}$$

where
- a = cross-sectional area of standpipe (cm^2)
- L = thickness of fabric sample (cm)
- A = cross-sectional area of flow through the fabric

t = time in seconds for head of water in standpipe to drop from h_0 to h_1

h_0, h_1 = head between which the permeability is determined (20 cm and 10 cm respectively)

For the apparatus described in this test procedure a = p $(1)^2$ and A = p $(0.5)^2$, therefore Equation 1 becomes:

$$k = \left(\frac{4L}{t}\right)\left(\ln \frac{h_0}{h_1}\right) \qquad \text{(Eq. 2.)}$$

X1.6.2 Flow Rate:

Flow rate is defined as the flow per unit area through a filter fabric for a given drop in the head of water above the fabric.

The equation for flow rate (FR) follows:

$$FR = \frac{Q}{tA} \qquad \text{(Eq. 3.)}$$

where t = time in seconds required for head to drop from h_0 to h_1

Q = volume of flow passing through the fabric

A = cross-sectional area of flow through fabric (cm^2)

By the continuity equation $Q = a(h_0 - h_1)$ where a = cross-sectional area of the permeameter standpipe/tank, h_0 = original height of water above the fabric (e.g., 20 cm), and h_1 = final height weight (e.g., 10 cm). For this test procedure a = 3.14 $in.^2$ (20.26 cm^2) and the area of flow is A - 0.79 $in.^2$ (5.07 cm^{-2}).

Substituting these values, Equation 3 becomes:

$$FR = \left(\frac{a}{A}\right)\left(\frac{h_o - h_1}{t}\right) = \frac{4\left(h_0 - h_1\right)}{t} \qquad \text{(Eq. 4.)}$$

X1.7 REPORTING RESULTS

Report k and FR as the average of the five values obtained from this Test Procedure. The calculated values of "k" are corrected to k 20°C, the permeability coefficient at 20°C using the following equation:

$$k_{20°C} = k \frac{u_t}{u_{20°C}}$$

where u_t = viscosity of water at temperature of water in system u 20°C = viscosity of water at 20°C = 10.09 millipoises.

FALLING HEAD PERMEABILITY DATA SHEET

Fabric I.D.: _____ DATE: _____

Sample Thickness (L): _____

Cross-sectional Area of Standpipe (a): _____

Cross-sectional Area of Flow through Fabric (A): _____

	t sec
1	
2	
3	
4	
5	
*Avg.	

Coefficient of Water Permeability: $k = \left(\frac{La}{AT}\right)\left(\ln \frac{h_0}{h_1}\right) =$

$$k_{20} = k \frac{U_t}{u_{20°C}} =$$

Flow Rate F. R. $= \left(\frac{a}{A}\right)\left(\frac{(h_0 - h_1)}{t}\right) =$

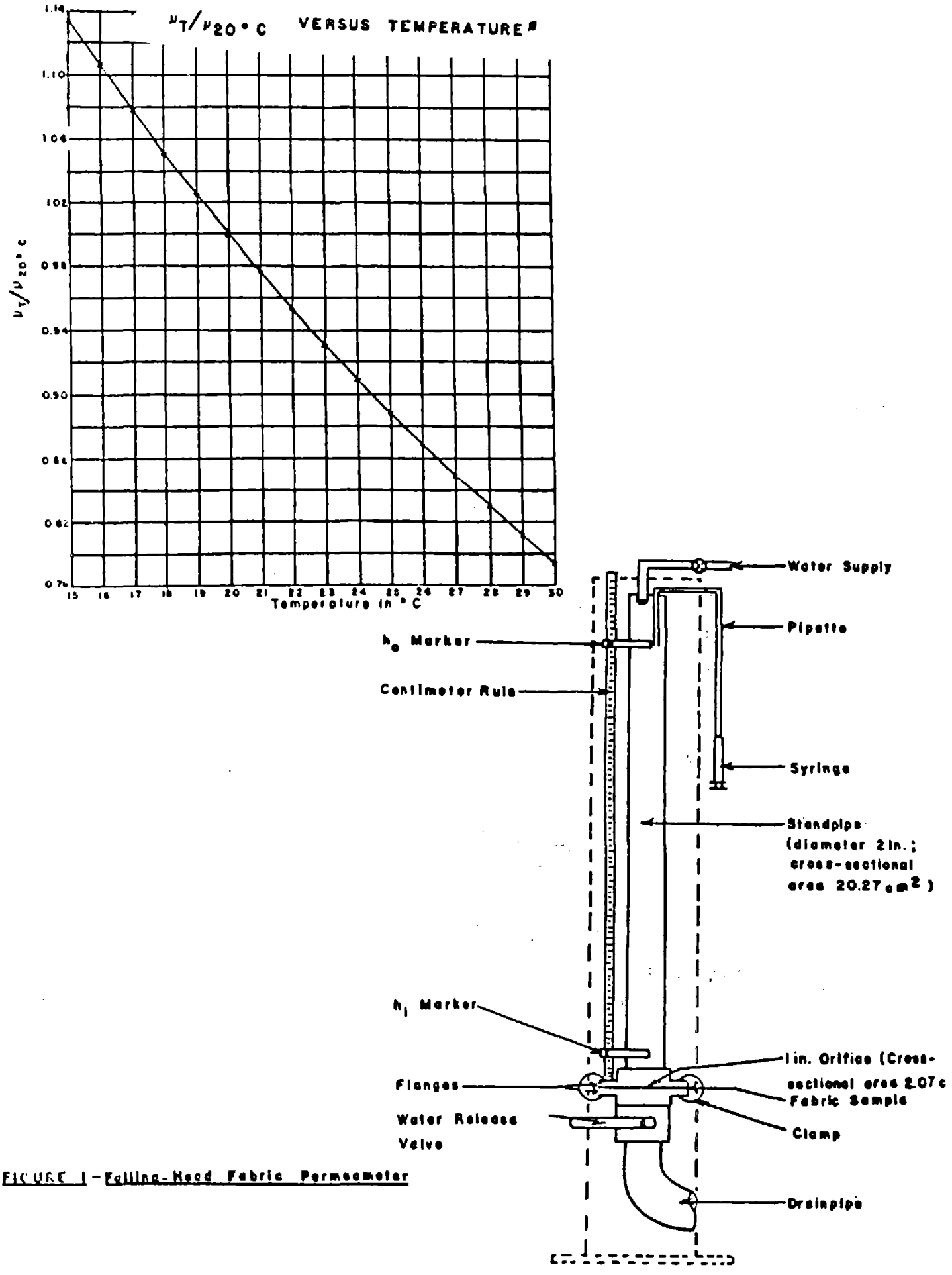

FIGURE 1 - Falling-Head Fabric Permeameter

APPENDIX C

TASK FORCE #25 GUIDELINES

APPENDIX C
Task Force 25 (AASHTO-ABC-ARBTA)

SPECIFICATION GUIDE FOR
DRAINAGE GEOTEXTILES - APPROVED BY TELEPHONE BALLOT
JULY, 1986

1. Description

1.1 This work shall consist of furnishing and placing a geotextile for the following drainage applications: edge of pavement drains,interceptor drains, wall drains, recharge basins, and relief wells. The geotextile shall be designed to allow passage of water while retaining in-situ soil without clogging. The quantities of drainage geotextiles as shown on the plans may be increased or decreased at the direction of the Engineer based on construction procedures and actual site conditions that occur during construction of the project. Such variations in quantity will not be considered as alternatives in the details of construction or a change in the character of the work.

2. Materials

2.1 Fibers used in the manufacture of geotextile, and the threads used in joining geotextiles by sewing, shall consist of long chain synthetic polymers composed of at least 85% by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selveges. These materials shall conform to the physical requirements of Table 1.

2.2 Geotextile rolls shall be furnished with suitable wrapping for protection against moisture, and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover.

3. Construction Requirements

3.1 Geotextile Exposure Following Placement - Exposure of geotextiles to the elements between lay down and cover shall be a maximum of 14 days to minimize damage potential.

3.2 Geotextile Placement - Figures 1 through 5 (not included here) illustrate various geotextile drainage application details.

In trenches, after placing the backfill material, the geotextile shall be folded over the top of the filter material to produce a minimum overlap of 12 inches for trenches greater than 12 inches wide. In trenches less than 12 inches in width, the overlap shall be equal to the width of the trench. The geotextile shall then be covered with the subsequent course.

Successive sheets of geotextiles shall be overlapped a minimum of 12 inches in the direction of flow.

3.3 Seams - Where seams are required in the longitudinal trench direction, they shall be joined by either sewing or overlapping. All seams shall be subject to the approval of the Engineer.

Overlap seams shall have a minimum overlap equal to the width of the trench.

3.4 Repair - A geotextile patch shall be placed over the damaged area and extend 3 feet beyond the perimeter of the tear or damage.

4. Method of Measurement

4.1 The geotextile shall be measured by the number of square yards computed from the payment lines shown on the plans or from payment lines established in writing by the Engineer. This excludes seam overlaps.

4.2 Excavation, backfill, bedding, and cover material are separate pay items.

5. Basis of Payment

5.1 The accepted quantities of geotextile shall be paid for at the contract unit price per square yard in place.

5.2 Payment will be made under:

Pay Item	Pay Unit
Drainage Geotextile	square yard

TABLE 1
PHYSICAL REQUIREMENTS[1,2]
FOR DRAINAGE GEOTEXTILES

Property	Drainage[3] Class A[4]	Class B[5]	Test Method
Grab Strength (lbs.)	180	80	TF 25 #1
Elongation (%)	N/A	N/A	TF 25 #1
Seam Strength[6] (lbs.)	160	70	TF 25 #1
Puncture Strength (lbs.)	80	25	TF 25 #4
Burst Strength (psi)	290	130	TF 25 #3
Trapezoidal Tear (lbs.)	50	25	ASTM D 4533
Apparent Opening Size US Std. Sieve	1. Soil with 50% or less particles by weight passing US No. 200 Sieve, AOS less than 0.6 mm (greater than #30 US Std. Sieve) 2. Soil with more than 50% particles by weight passing US No. 200 Sieve, AOS less than 0.927 mm (greater than #50 US Std. Sieve)		TF 25 #6
Permeability[7] (cm/sec)	k fabric > k soil for all classes		ASTM D4491-85
Ultraviolet Degradation at 150 hours	70% Strength retained for all classes		ASTM D4355

1. Acceptance of geotextile material shall be based on FT 25 Acceptance/Rejection Guidelines.

2. Contracting agency may require a letter from the supplier certifying that its geotextile meets specification requirements.

3. Minimum - Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table). - Stated values are for non-critical, non-severe applications. Lots sampled according to ASTM D4354.

4. Class A Drainage applications for fabrics are where installation stresses are more severe than Class B applications, i.e., very coarse sharp angular aggregate is used, a heavy degree of compaction (95% AASHTO T99) is specified or depth of trench is greater than 10 feet.

5. Class B Drainage applications are those where fabric is used with smooth graded surfaces having no sharp angular projections, no sharp angular aggregate is used; compaction requirements are light, (< 95% AASHTO T99), and trenches are less than 10 feet in depth.

6. Values apply to both field and manufactured seams.

7. A nominal coefficient of permeability may be determined by multiplying permittivity value by nominal thickness. The k value of the fabric should be greater than the k value of the soil.

SPECIFICATION GUIDE FOR
EROSION CONTROL GEOTEXTILES - APPROVED BY TELEPHONE BALLOT
JULY, 1986

1. Description

1.1 This work shall consist of furnishing and placing a geotextile for the following erosion control applications: cut and fill slope protection, protection of various small drainage structures and ditches, wave protection for causeways and shore line roadway embankments, and scour protection for structures such as bridge piers and abutments. The geotextile shall be designed to allow passage of water while retaining insitu soil without clogging. The quantities of erosion control geotextiles as shown on the plans may be increased or decreased at the direction of the Engineer based on construction procedure and actual site conditions that occur during construction of the project. Such variations in quantity will not be considered as alternations in the details of construction or a change in the character of the work.

2. Materials

2.1 Fibers used in the manufacture of geotextile, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 85% by weight of polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvedges. These materials shall conform to the physical requirements of Table 1.

2.2 Geotextile rolls shall be furnished with suitable wrapping for protection against moisture, and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover.

3. Construction Requirements

3.1 Geotextile Exposure Following Placement - Exposure of geotextiles to the elements between lay down and cover shall be maximum of 14 days to minimize damage potential.

3.2 Erosion Control Placement - The geotextile shall be placed and anchored on a smooth graded surface approved by the Engineer. The geotextile shall be placed in such a manner that placement of the overlying materials will not

excessively stretch or tear the fabric. Anchoring of the terminal ends of the geotextiles shall be accomplished through the use of key trenches or aprons at the crest and toe of slope. Refer to Figures 1 through 4 (not included here) for construction details.

NOTE: In certain applications to expedite construction, 18-inch long anchoring pins placed on 2 to 6 feet centers depending on the slope of the covered area have been used successfully.

3.2.1 Slope Protection Placement

Successive geotextile sheets shall be overlapped in such a manner that the upstream sheet is placed over the downstream sheet and/or upslope over downslope. In underwater aplications, the geotextile and required thickness of backfill material shall be placed the same day. The backfill placement shall begin at the toe and proceed up the slope.

Riprap and heavy stone shall not be dropped onto the geotextile from the height of more than 1 foot. Slope protection and smaller sizes of stone filling shall not be dropped onto the geotextile from a height exceeding 3 feet. Any geotextile damaged during placement shall be replaced as directed by the Engineer at the Contractor's expense.

3.3 Seams - The geotextile shall be joined by either sewing or overlapping. All seams shall be subject to the approval of the Engineer.

Overlapped seams shall have a minimum overlap of 12 inches except where placed under water where the overlap shall be a minimum of 3 feet.

3.4 Repair - A geotextile patch shall be placed over the damaged area and extend 3 feet beyond the perimeter of the tear or damage.

4. Method of Measurement

4.1 The geotextile shall be measured by the number of square yards computed from the payment lines shown on the plans or from payment lines established in writing by the Engineer. This excludes seam overlaps, but shall include geotextiles used in crest and toe of slope treatments.

4.2 Slope preparation, excavation and backfill, bedding, and cover material are separate pay items.

5. Basis of Payment

5.1 The accepted quantities of geotextile shall be paid for per square yard in place.

5.2 Payment will be made under:

Payment Item	Pay Unit
Erosion Control Geotextile	square yard

TABLE 1
PHYSICAL REQUIREMENTS[1,2]
FOR EROSION CONTROL GEOTEXTILES

Property	Erosion Control[3] Class A[4]	Class B[5]	Test Method
Grab Strength (lbs)	200	90	TF 25 #1
Elongation (%) (min)	15	15	TF 25 #1
Seam Strength (lbs)[6]	180	80	TF 25 #1
Puncture Strength (lbs)	80	40	TF 25 #4
Burst Strength (psi)	320	140	TF 25 #3
Trapezoid Tear (lbs)	50	30	ASTM D 4533
Apparent Opening Size US Std. Sieve	1. Soil with 50% or less particles by weight passing US No. 200 Sieve, AOS less than 0.6 mm (greater than #30 US Std. Sieve) 2. Soil with more than 50% particles by weight passing US No. 200 Sieve, AOS less than 0.297 mm (greater than #50 US Std. Sieve)		TF 25 #6
Permeability[7] (cm/sec)	k fabric > k soil for all classes		ASTM D4491-85
Ultraviolet Degradation at 150 hours	70% Strength Retained for all classes		ASTM D4335

1. Acceptance of geotextile material is to be based on TF 25 Acceptance/Rejection Guidelines.

2. Contracting agency may require a letter from the supplier certifying that its geotextile meets specifications requirements.

3. Minimum - Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the table). - Stated values are for non-critical, non-severe conditions. Lot sampled according to ASTM D4354.

4. Class A Erosion Control applications are those where fabrics are used under conditions where installation stresses are more severe than Class B, i.e., stone placement height should be less than 3 feet and stone weights should not exceed 250 pounds.

5. Class B Erosion Control applications are those where fabric is used in structures or under conditions where the fabric is protected by a sand cushion or by "zero drop height" placement of stone.

6. Values apply to both field and manufactured seams.

7. A nominal coefficient of permeability may be determined by multiplying permittivity value by nominal thickness. The k value of the fabric should be greater than the k value of the soil.

Appendix "C" (continued) -TASK FORCE 25

SPECIFICATION GUIDE FOR
TEMPORARY SILT FENCE - APPROVED BY TELEPHONE BALLOT
JULY, 1986

1. Description

1.1 This work shall consist of furnishing, installing, maintaining, and removing a geotextile barrier-fence designed to remove suspended particles from the water passing through it. The quantities of temporary silt fence shown on the plans may be increased or decreased at the direction of the Engineer based on weather, construction procedures, and actual site conditions that occur during construction of the project. Such variations in quantity will not be considered as altercations in the details of construction or a change in the character of the work.

2. Materials

2.1 This specification provides criteria for wire supported geotextile silt fence as well as a self supporting geotextile silt fence.

2.2 Fibers used in the manufacture of geotextiles shall consist of long-chain synthetic polymers, composed of at least 85% by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvedges. The geotextile shall conform to the requirements shown in Table 1. The geotextile shall be free of any treatment or coating which might adversely alter its physical properties after installation.

2.3 Geotextile rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide produce identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements.

2.4 Posts: Either wood, steel, or synthetic posts may be used. Posts shall have a minimum length of 36 inches plus burial depth and be of sufficient strength to resist damage during installation and to support applied loads.

2.5 Support Fence: Wire or other support fence shall be at least 32 inches high and strong enough to support applied loads.

2.6 Prefabricated Fence: Prefabricated fence systems may be used provided they meet all of the above material requirements.

Remarks

It has been found that oak posts having dimensions of at least 1 1/4 inches ¥ 1 1/4 inches or steel posts of U, T, L or C shape weighing 1.3 pounds per linear foot have performed satisfactorily. In soft ground, swamps, etc., a wider post is advantageous as additional passive resistance needs to be developed.

Wire support fence having at least 6 horizontal wires, and being at least 12-gauge wire have performed satisfactorily. Vertical wires should be spaced a maximum of 6 inches apart.

3. Construction Requirements

3.1 The Contractor shall install a temporary silt fence as shown on the plans, and at other locations as directed by the Engineer. Fence construction shall be adequate to handle the stress from sediment loading. Geotextile at the bottom of the fence shall be buried a minimum of 6 inches in a trench so that no flow can pass under the barrier. The trench shall be backfilled and the soil compacted over the geotextile. Fence height shall be as specified by the Engineer but in no case shall exceed 36 inches above ground surface. The geotextile shall be spliced together only at a support post with a minimum 6-inch overlap. See Figure 1 (not included here) for details.

Remarks

It is recommended that posts be spaced a maximum of 8 feet apart and where possible placed or driven a minimum of 18 inches into the ground. Where an 18 inch depth is impossible to achieve, the posts should be adequately secured to prevent overturning of the fence due to sediment loading.

3.2 When wire support fence is used, the wire mesh shall be fastened securely to the up slope side of the post. The wire shall extend into the trench a minimum of 2 inches and extend a maximum of 36 inches above the original ground surface.

3.3 When self supported fenced is used, the geotextile shall be securely fastened to fence posts.

Remarks

Typical locations include the toe of fill slopes, the downhill side of large cut areas, along streams, and at natural drainage areas. Silt fences should be continuous and transverse to the flow, and limited to handle an area equivalent to 1,000 square feet per 10 feet of fence. Caution should be used where the side slope is steeper than 1:1, and water flow exceeds 1 cubic foot per second per 10 feet of fence.

3.4 It is the Contractor's responsibility to maintain the integrity of silt fences as long as they are necessary to contain sediment runoff. The Contractor shall inspect all temporary silt fences immediately after each rainfall and at least daily during prolonged rainfall. Any deficiencies shall be immediately corrected by the Contractor. In addition, the Contractor shall make a daily review of the location of silt fences in areas where construction activities have changed the natural contour and drainage runoff to ensure that the silt fences are properly located for effectiveness. Where deficiencies exist, additional silt fences shall be installed as directed by the Engineer. Should the silt fence become damaged or otherwise ineffective while the barrier is still necessary, it shall be repaired promptly.

3.5 Sediment deposits shall either be removed when the deposit reaches approximately one-half of the height of the silt fence or a second silt fence shall be installed as directed by the Engineer.

3.6 The silt fence shall remain in place until the Engineer directs that it be removed. Upon removal, the Contractor shall remove and dispose of any excess silt accumulations, dress the area to give a pleasing appearance, and vegetate all bare areas in accordance with the contract requirements. The fence materials will remain the property of the Contractor and may be used at other locations provided the materials meet the requirements in Table 1.

5. Method of Measurement

5.1 Temporary silt fence will be measured in linear feet, complete in place.

5.2 Removed Sediment will be measured by the cubic yard.

6. Basis of Payment

6.1 Temporary silt fence will be paid for per linear foot which shall be full compensation for completing the work specified. Such payment shall be full compensation of furnishing all materials, erecting, maintaining, and removing the fence.

6.2 Removing of accumulated silts shall be paid for by cubic yards.

6.3 Dressing and grassing will be paid for by acre.

6.4 Payment will be made under:

Pay Item	Pay Unit
Silt Fence	Linear Foot
Removing Sediments	Cubic Yards
Grassing	Acre

TABLE 1
PHYSICAL REQUIREMENTS[1,2]
FOR TEMPORARY SILT FENCE GEOTEXTILES

Property	Test Method	Wire Fence Supported Requirements	Self Supported Requirements
Tensile Strength (lbs.)	TF 25 Method #1 (Grab)	90 minimum[3]	90 minimum
Elongation at 50% minimum tensile strength (45 lbs)	TF 25 Method #1 (Grab)	N/A	50 maximum
Permittivity[4] (sec^{-1})	ASTM D4491	.01 minimum	.01 minimum
Apparent Opening[4] Size (mm)	TF 25 Method #6	.84 maximum	.84 maximum
Ultraviolet[5]	ASTM D4355	Minimum 70% Strength Retained	Minimum 70% Strength Retained

1. Acceptance of geotextile material to be based on TF 25 Acceptance/ Rejection Guidelines.

2. Contracting agency may require a letter from the supplier certifying that its geotextile meets specification requirements.

3. Minimum - Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the tables) - Stated values are for non-critical, non-severe conditions. Lot sampled according to ASTM D4354.

4. Permittivity and AOS do not relate directly to filtration performance of silt fence fabrics. Values presented reflect minimum criteria of products currently used. Performance tests such as VTM-51 (from Virginia Highway Research Council) may be used to evaluate silt fence performance if deemed necessary by the Engineer.

5. Strength retained after 500 hours of ultraviolet exposure when tested according to ASTM D4355. This method specified tensile testing by 2-inch strip (or ravelled strip) for both control and exposed samples.

SPECIFICATIONS FOR
PAVING FABRICS - JANUARY 13, 1985

1. Description

Work shall consist of furnishing and placing a fabric between pavement layers for the purpose of incorporating a waterproofing and stress relieving membrane within the pavement structure. This specification guide is applicable to fabric membranes used for full coverage of the pavement, or as strips over transverse and longitudinal pavement joints. It is not intended to describe membrane systems specifically designed for pavement joints and localized (spot) repairs.

2. Materials

2.1 Paving Fabric: The fabric used with this specification shall be constructed of nonwoven synthetic fibers; resistant to chemical attack, mildew, and rot; and shall meet the following physical requirements:

Property	Requirements	Task Method
Tensile Strength (lbs.)	80 minimum*	Task Force 25 Method 1
Elongation-at-Break (%)	50 minimum	Task Force 25 Method 1
Asphalt Retention (gal./sq. yd.)	0.2 minimum	Task Force 25 Method 8
Melting Point (degrees F)	300 or greater	ASTM D 276

*Minimum - Value in weaker principal direction. All numerical values represent minimum average roll values (i.e., any roll in a lot shall meet or exceed the minimum values in the table).

Remarks

TF25 test methods are recommended because current applicable ASTM test procedures allow too much variability in the equipment, test procedures, and reporting. The methods recommended were actually developed by the ASTM committee on Geotextiles and INDA. These procedure are currently being processed for acceptance by ASTM.

2.2 Asphalt Sealant: The material used to impregnate and seal the fabric, as well as bond it to both the base pavement and overlay, shall be a paving grade asphalt recommended by the fabric manufacturer and approved by the engineer.

Uncut asphalt cements are the preferred sealant; however, cationic and anionic emulsions may be used provided the precautions outlined in section 4.4 are followed. Cutbacks and emulsions which contain solvents shall not be used.

Remarks

The grade of asphalt cement specified for hot-mix design in each geographic location is generally the most acceptable material.

2.3 Aggregate: Washed concrete sand may be spread over asphalt-saturated fabric to facilitate movement of equipment during construction or to prevent tearing or delamination of the fabric. Hot-mix broadcast in front of construction vehicle tires may also be used to serve this purpose. If sand is applied, excess quantities shall be removed from the fabric prior to placing the surface course.

Remarks

Sand is not usually required. However, ambient temperatures are occasionally sufficiently high to cause bleed-through of the asphalt sealant resulting in undesirable fabric adhesion to construction vehicle tires.

3. Equipment

3.1 Asphalt Distributor: The distributor shall be capable of spraying the asphalt sealant at the prescribed uniform application rate. No streaking, skipping, or dripping will be permitted. The distributor shall also be equipped with a hand spray having a single nozzle and positive shut-off valve.

3.2 Fabric Handling Equipment: Mechanical or manual laydown equipment shall be capable of laying the fabric smoothly.

3.3 Miscellaneous Equipment: Stiff bristle brooms or squeegees to smooth the fabric, scissors or blades to cut the fabric, and brushes for applying asphalt sealant at fabric overlaps shall be provided. Pneumatic rolling equipment to smooth the fabric into the sealant and sanding equipment may be required for certain jobs.

Rolling is especially required on jobs where thin lifts or chip seals are being placed. Rolling helps ensure fabric bond to adjoining pavement layers in the absence of the heat and weight associated with thicker lifts of asphaltic pavement. An example of when rolling is extremely important is when the ambient temperature is so low that the normal wicking of the asphalt sealant into the fabric does not occur.

4. Construction Methods/Requirements

4.1 Fabric Packaging and Storing: Fabric rolls shall be furnished with suitable wrapping for protection against moisture and extended ultra-violet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover.

4.2 Weather Limitations: Neither the asphalt sealant nor fabric shall be placed when weather conditions, in the opinion of the engineer, are not suitable. Air and pavement temperatures shall be sufficient to allow the asphalt sealant to hold the fabric in place. For asphalt cements, air temperature shall be 50°F and rising. When using asphalt emulsions, air temperature shall be 60°F and rising.

4.3 Surface Preparation: The surface on which the fabric is to be placed shall be reasonably of dirt, water, vegetation, or other debris. Cracks exceeding 1/8 inch in width shall be filled with a suitable crack filler and potholes shall be properly repaired as directed by the engineer. The crack fillers shall be allowed to cure prior to fabric placement.

Remarks

If the condition of the existing pavement is such that a simple crack fill operation is not adequate for surface preparation, then it may be more economical to place a leveling course prior to placing the fabric.

4.4 Application of Asphalt Sealing: The asphalt sealant shall be uniformly spray applied to the prepared dry pavement surface at the rate 0.20 to 0.30 gallons per square yard or as recommended by the fabric manufacturer and approved by the engineer.

Application of the sealant shall be by the distributor spray bar, with hand spraying kept to a minimum. Temperature of the asphalt sealant shall be sufficiently high to permit a uniform spray pattern.

For asphalt cements the minimum temperature shall be 290°F to avoid damage to the fabric, however, distributor tank temperatures shall not exceed 325°F. Spray patterns for asphalt emulsion are improved by heating. Temperatures in the 130 to160°F range are desirable. A temperature of 160°F shall not be exceeded since higher temperatures may break the emulsion.

The target width of asphalt sealant application shall be fabric width plus 6 inches. The asphalt sealant shall not be applied any farther in advance of fabric placement than the distance which the contractor can maintain free of

traffic.

Asphalt spills shall be cleaned from the road surface to avoid flushing and fabric movement.

When asphalt emulsions are used, the emulsion shall be cured (essentially no moisture remaining) prior to placing the fabric and final wearing surface.

Remarks

The rate specified must be sufficient to satisfy the asphalt retention properties of the fabric and bond the fabric and overlay to the old pavement. In order to account for the variables in pavement texture and precision of distributor truck operation a rate of at least 0.20 gallons per square yard should be specified. Rough and ravelled surfaces may require a higher application rate. Within street intersections, on steep grades, or in other zones where vehicle speed changes are commonplace, the normal application rate should be reduced by about 20 percent, but no less than 0.20 gallons per square yard or as specified by the manufacturer. Note: When using emulsions the application rate must be increased to offset water content of the emulsion.

4.5 Fabric Placement: The fabric shall be placed into the asphalt sealant with minimum wrinkling prior to the time the asphalt has cooled and lost tackiness. As directed by the engineer, wrinkles or folds in excess of 1 inch shall be slit and laid flat. Brooming and/or pneumatic rolling will be required to maximize fabric contact with the pavement surface.

Overlap of fabric joints shall be sufficient to ensure full closure of the joint, but should not exceed 6 inches. Transverse joints shall be lapped in the direction of paving to prevent edge pickup by the paver. A second application of asphalt sealant to fabric overlaps will be required if in the judgement of the engineer additional asphalt sealant is needed to ensure proper bonding of the double fabric layer.

Removal and replacement of fabric that is damaged will be the responsibility of the contractor.

Remarks

The problems associated with wrinkles are related to thickness of the asphalt lift being placed over the fabric. When wrinkles are large enough to be folded over, there usually is not enough asphalt available from the tack coat to satisfy the requirement of the multiple layers of fabric. Therefore, wrinkles should be slit and laid flat. Sufficient asphalt sealant should be sprayed on the top of the fabric to satisfy the requirement of the lapped fabric. In overlapping adjacent rolls of fabric it is desirable to keep the lapped dimension as small as possible and still provide a positive overlap. If the lapped dimension becomes too large, the problem of inadequate tack to satisfy the two lifts of fabric and the old pavement may occur. If this problem does occur then

additional asphaltic sealant should be added to the lapped areas. In the application of additional asphalt sealant, care should be exercised not to apply too much since an excess will cause flushing.

4.6 Fabric Trafficking: Trafficking the fabric will be permitted for emergency or construction equipment only.

4.7 Asphalt Overlay: Placement of the hot mix overlay should closely follow fabric laydown. The temperature of the mix shall not exceed 325°F. In the event asphalt bleeds through the fabric causing construction problems before the overlay is placed, the affected areas shall be blotted by spreading sand or hot-mix. To avoid movement or damage to the fabric membrane, turning of the paver and other vehicles shall be gradual and kept to a minimum.

4.8 Seal coats: Prior to placing a seal coat (or thin overlay such as an open-graded friction course), lightly sand the fabric at a spread rate of 1 1/2 to 2 pounds per square yard and pneumatically roll the fabric tightly into the sealant.

Remarks

The task force believes that trafficking of the fabric should not be allowed due to safety considerations. If the contracting agency policy allows trafficking of the fabric then the following verbage is recommended:

> "If approved by the engineer, the membrane may be opened to traffic for 24 to 48 hours prior to installing the surface course. Warning signs may be placed which advise the motorist that the surface may be slippery when wet. The signs shall also post the appropriate safe speed. Excess sand shall be broomed from the fabric surface prior to placing the overlay. If, in the judgement of the engineer, the fabric surface appears dry and lacks tackiness following exposure to traffic, a light tack coat will be applied prior to the overlay."

5. Method of Measurement

5.1 The paving fabric will be measured by the square yard.

5.2 Asphalt sealant for the paving fabric will be measured by the gallon.

6. Basis of Payment

6.1 The accepted quantities of paving fabric will be paid for at the contract unit price per square yard in place.

6.2 The accepted quantities of asphalt sealant for the paving fabric will be paid for at the contract unit price per gallon complete in place.

6.3 Payment will be made under:

Pay Item	Pay Unit
Paving Fabric	square yad
Asphalt Sealant for Paving Fabric	gallon

Appendix "C" (continued) -TASK FORCE 25

SPECIFICATION FOR SURVIVABILITY

Table 1 AASHTO-ABC-ARBTA Joint Committee Minimum Fabric Properties Required for Fabric Survivability[a]

Required degree of fabric survivability	Grab strength (lb)	Puncture strength[b] (lb)	Burst strength[c] (psi)	Trap tear[d] (lb)
Low	90	30	145	30
Moderate	130	40	210	40
High	180	75	290	50
Very high	270	110	430	75

[a]All values represent minimum values (i.e., any roll in a lot should meet or exceed the minimum values in this table).
[b]ASTM D751-68, tension testing machine with ring clamp, steel ball replaced with a 5/16-in.-diameter solid steel cylinder with hemispherical tip centered within the ring clamp.
[c]ASTM D751-68, diaphragm test method.
[d]ASTM D1117, either principal direction.

Note: The above specifications for fabric installation survivability has not been formally adopted by Task Force #25 as of January 1, 1989. Thus it still is in an interim status. The required degree of fabric survivability referenced in the above table is to be used with Table 2 following.

Table 2 - Required Degree of Survivability as a Function of Subgrade Conditions and Construction Equipment[a]

Subgrade conditions	Construction equipment and 6-12 in. of cover material: initial lift thickness		
	Low-grade pressure equipment (≤4 psi)	Medium ground-pressure equipment (>4 psi, ≤8 psi)	High-ground pressure equipment (>8psi)
Subgrade has been cleared of all obstacles except grass, weeds, leaves, and fine wood debris. Surface is smooth and level such that any shallow depressions and humps do not exceed 6 in. in depth and height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low	Moderate	High
Subgrade has been cleared of obstacles larger than small to moderate-sized tree limbs and rocks. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 18 in. in depth and height. Larger depressions should be filled.	Moderate	High	Very high
Minimal site preparation is required. Trees may be felled, delimbed, and left in place. Stumps should be cut to project not more than 6 in. ± above subgrade. Fabric may be draped directly over tree trunks, stumps, large depressions and humps, holes, steam channels, and large boulders. Items should be removed only if placing the fabric and cover material over them will distort the finished road surface.	High	Very high	Not recommended

[a]Recommendations are for 6-12 in. initial lift thickness. For other initial lift thickness:
12-18 in: reduce survivability requirement one level
18-24 in.: reduce survivability requirement two levels
>24 in.: reduce survivability requirement three levels
Survivability levels are, in increasing order: low, moderate, high and very high.
For special construction techniques such as pre-rutting, increase fabric survivability requirement or level.
Placement of excessive initial cover material thickness may cause bearing failure of soft subgrade.
Source: After Christopher, B., Holtz, R. D. and DiMaggio, J., Federal Highway Administration (DOT) Training Manual, Washington, DC.

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