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Geosynthetics:
Specifications and Applications for Arizona, Volume 2

Arizona Department of Transportation Research Center

ADOT

Geosynthetics – Specifications and Applications for Arizona

SPR-722

Volume 2: Appendices

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16. Abstract
The purpose of this Arizona Department of Transportation (ADOT) research study was (1) to update the ADOT geosynthetic specifications for geogrids, geotextiles, geomembranes, and composites; and (2) to recommend design guidelines for using geosynthetics for base reinforcement and subgrade stabilization. The study included a survey of other states regarding their material specifications for geosynthetics and their design guidelines for using geosynthetics for base reinforcement and subgrade stabilization. The study also included a review of available research, studies, and design methods for using geosynthetics for base reinforcement and subgrade stabilization. Recommended design guidelines were developed for ADOT on the basis of the review. The costs of using geosynthetics for base reinforcement and subgrade stabilization were analyzed. The analysis compared the construction costs for design alternatives with and without geosynthetics using the recommended design guidelines. The cost comparisons focused exclusively on construction costs (i.e., installed materials). There were insufficient data in the literature to develop a life-cycle cost analysis for geosynthetic use in pavements. It was determined that geosynthetics can be cost-effective for base reinforcement and subgrade stabilization. The cost savings is dependent on the design conditions, the type of geosynthetic used, and the material costs. Finally, new ADOT material specifications for geosynthetics were recommended, and revisions to the installation specifications were suggested. The recommendations were based on the results of the surveys, research, evaluations, and design guidelines developed through this project.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

Contents

LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO — American Association of State Highway and Transportation Officials
AB — aggregate base
ABC — aggregate base course
AC — asphaltic concrete
ADOT — Arizona Department of Transportation
ADT — average daily traffic
AGC — Association of General Contractors
Alaska DOT&PF —Alaska Department of Transportation and Public Facilities
AOS — apparent opening size
APL — approved products list
ARTBA — American Road and Transportation Builders Association
ASCE-GI — American Society of Civil Engineers Geo-Institute
ASTM — American Society for Testing and Materials
BCR — base course reduction
c — subgrade shearstrength
Caltrans — California Department of Transportation
CBR — California Bearing Ratio
CFLHD — Central Federal Lands Highway Division
cm — centimeter
C&S — Contracts and Specifications (ADOT)
DCP — dynamic cone penetrometer
DOTs — Departments of Transportation
ESAL — equivalent single axle load
FAA — Federal Aviation Administration
FHWA — Federal Highway Administration
ft — foot
FWD — falling weight deflectometer
g — gram
gal — gallon
GMA — Geosynthetic Materials Association
GSI — Geosynthetics Institute
HMA — hot mix asphalt
HQ AFCEC — Air Force Civil Engineer Center
hr — hour
IGS — International Geosynthetics Society
IGSNA — International Geosynthetics Society North America Chapter
kN — kiloNewton
kPa — kilopascal
l — liter
lb — pound
LCR — layer coefficient ratio
m — meter
M_1 — subgrade modulus
MEPDG — Mechanistic-Empirical Pavement Design Guide

mg — milligram
min — minute
mm — millimeter
MPEDM — Materials Preliminary Engineering and Design Manual
MSE — mechanically stabilized earth (walls)
N — Newton
NAGS — North American Geosynthetics Society
NASA — National Aeronautics and Space Administration
NAVFAC — Naval Facilities Engineering Command
N/A — not applicable
N_C — bearing capacity factor
NHI — National Highway Institute
NTPEP — National Transportation Product Evaluation Program
oz — ounce
Pa — Pascal
PI — plasticity index
psf — pounds per square foot
psi — pounds per square inch
PSI — Pavement Serviceability Index (PSI)
Δ PSI – change in pavement serviceability index
PVC — polyvinyl chloride
QPL — qualified products list
R-Value — resistance value
sec — second
SEG — Subgrade Enhancement Geosynthetic
SEG_G — Subgrade Enhancement Geogrid
SEG_T — Subgrade Enhancement Geotextile
SN — structural number
Standard Specifications — ADOT Standard Specifications for Road and Bridge Construction
SVF — seasonal variation factor
SY — square yard
TAC — Technical Advisory Committee
TBR — traffic benefit ratio
TRB — Transportation Research Board
USACE — USArmy Corps of Engineers
UFGS — Unified Facilities Guide Specifications
USFS — USDA Forest Service
UV — ultraviolet
WES — Waterways Experiment Station
yd — yard

REFERENCES

Al-Qadi, Imad L. and Appea, Alexander Kwasi. 2003. "Eight-Year Field Performance of Secondary Road Incorporating Geosynthetics at Subgrade-Base Interface." Paper No. 03-3453, Transportation Research Board.

American Association of State, Highway and Transportation Officials (AASHTO). 1986. "Guide for Design of Pavement Structures."

———. 2007. "Standard Specification for Geotextile Specification for Highway Applications." AASHTO M288-06.

———. 2009. "Standard Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures." AASHTO Standard R 50-09.

———. 2013. "Recommended Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures." AASHTO Standard: R 50-09.

Arizona Department of Transportation (ADOT). 1992. "Materials Preliminary Engineering and Design Manual." http://www.azdot.gov/docs/businesslibraries/ped.pdf?Status=Master&sfvrsn=4 [accessed 2/25/2014]

———. 2008. "Standard Specifications for Road and Bridge Construction–2008." http://www.azdot.gov/docs/default-source/business/download-2008-stored-specifications-122713.exe?sfvrsn=10 [accessed 2/25/2014]

———. 2011. "Construction Manual." http://www.azdot.gov/business/engineering-and-construction/construction/ConstructionManual/construction-manual [accessed 2/25/2014]

———. 2013a. "ADOT Materials Policy and Procedure Manual." http://www.azdot.gov/docs/default-source/businesslibraries/ppd.pdf?Status=Master&sfvrsn=11 [accessed 2/25/2014]

———. 2013b. "Construction Costs 2013." Contracts and Specifications.

———. 2014a. "Materials Testing Manual: Sampling and Testing Procedures." http://www.azdot.gov/docs/default-source/businesslibraries/adot-materials-testing-manual.pdf?sfvrsn=14 [accessed 2/25/2014]

———. 2014b. "Construction Costs 2014." Contracts and Specifications.

Barenberg, E.J., Hales, J. and Dowland, J. 1975. "Evaluation of Soil-Aggregate Systems with MIRAFI Fabric." University of Illinois Report No. UILU-ENG-75-2020, prepared for Celanese Fibers Marketing Company.

Berg, R.R., Christopher, B.R., and Perkins, S.W. 2000. “Geosynthetic Reinforcement of the Aggregate Base/Subbase Courses of Flexible Pavement Structures.” GMA white paper II. Geosynthetic Materials Association, Roseville, MN.

Bush, Amanda Joy and Brooks, Eric W. 2007. “Geosynthetic Materials in Reflective Crack Prevention, Final Report, SR 537.” Oregon Department of Transportation.

Button, J.W., Lytton, R.R. 2007. "Field Synthesis of Geotextiles in Flexible and Rigid Pavement Overlay Strategies Including Cost Considerations," Texas Department of Transportation.

Bygness, Ron, ed. 2009. “Geosynthetics: Recalling the Days of Yore.” *Geosynthetic*, 27(9): 38-41, October-November.

California Department of Transportation (Caltrans). 2012. “Aggregate Base Enhancement with Biaxial Geogrids for Flexible Pavements, Guidelines for Project Selection and Design.”

———. 2013. “Subgrade Enhancement Geosynthetic Design and Construction Guide.”

Christopher, Barry, Schwartz, Charles, Boudreau, Richard, 2006. "Geotechnical Aspects of Pavements" NHI Course No. 132040, Publication No. FHWA NHI-05-037, Federal Highway Administration.

Clyne, Timothy. 2011. "Monitoring Geosynthetics in Local Roadways (LRRB 768) 10-Year Performance Summary." Minnesota Department of Transportation.

Cuelho, E. and Perkins, S. 2009. “Field Investigation of Geosynthetics Used for Subgrade Stabilization.” Western Transportation Institute, Montana State University, Bozeman.

Cuelho, E., Perkins, S. and Morris, Z. 2014. MT-14-002/7712-251 “Relative Operational Performance of Geosynthetics Used As Subgrade Stabilization – Final Project Report.” Prepared by the Western Transportation Institute, Montana State University – Bozeman for State of Montana DOT.

Federal Aviation Administration (FAA). 1994. “Geogrid Reinforced Base Course.” Engineering Brief No. 49.

Florida Department of Transportation. 2011. “Geosynthetic Reinforcement Evaluation Experimental Project Status Report, Palm Beach County, Section/Subsection No. 93130-3508, State Road 15.” State Materials Office, Gainesville, Florida.

Giroud, J.P., Han J. 2004. "Design Method for Geogrid-Reinforced Unpaved Roads. Parts I and II." *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 130, No. 8, pp. 775-797.

Giroud, J.P. and Noiray, L. 1981. "Geotextile Reinforced Unpaved Road Design." *Journal of the Geotechnical Engineering Division*, ASCE, Vol. 107, No. GT9

Helstrom, Christopher L. 2005. "Performance and Effectiveness of a Thin Pavement Section Using Geogrids and Drainage Geocomposite in a Cold Region." Master's Thesis, University of Maine.

Holtz, R.D., Christopher, B.R., Berg, R.R., 2008. "Geosynthetic Design and Construction Guidelines. Reference Manual." NTIS Accession Number: PB99-130841. NHI Course No. 132013A, FHWA-NHI-07-092.

Houlsby, Guy T. and Jewell, Richard A. 1990. "Design of Reinforced Unpaved Roads for Small Depths." Fourth International Conference on Geotextiles, Geomembranes and Related Products, Netherlands.

Jersey, Sarah R., Tingle, Jeb S., Norwood, Gregory J., Kwon, Jayhyun, Wayne, Mark. 2012. "Full-Scale Evaluation of Geogrid-Reinforced Thin Flexible Pavements." *Transportation Research Record: Journal of the Transportation Research Board*, 2310 : 61-71.

Kestler, Maureen A. 2009. "Stabilization Selection Guide for Aggregate and Native-Surfaced Low Volume Roads." US Department of Agriculture (USDA) Forest Service.

Kim, Woon-Hyung, Tuncer, B. Edel, and Benson, Craig H. and Tanyu, Burak F. 2006. "Deflection of Prototype Geosynthetic-Reinforced Working Platforms over Soft Subgrade." *Transportation Research Record, Journal of the Transportation Research Board,* 1975: 137-145..

Koerner, Robert M. 2000. "Defining a Geosynthetic: Type and Functions." *Roads & Bridges*, accessed 7/25/2013.

Kuhlmann, B. and Marquart, M.J. 1998. "Base Reinforcement Using Geogrid." Experimental Study ND 91-01, Final Report. North Dakota DOT Materials and Research Division.

Lee, Min Sang, Choi, Yoon Seok and Prezzi, Monica. 2012. "Quality Assessment of Geogrids Used for Subgrade Treatment." Technical Report FHWA/IN/JTRP-2012/27, Joint Transportation Research Program, Purdue University.

Loegering, J., Mastel, A. & Marquart, M. 2013. " Base Reinforcement Using Geogrid, Fourth Evaluation Report." Experimental Study ND 2002-01, North Dakota DOT Materials and Research Division. http://www.dot.nd.gov/divisions/materials/research_project/nd0201report.pdf [accessed 1/9/2015]

Maher, M., Marshall, C., Harrison, F., Baumgaertner, K., 2005. FHWA "Context Sensitive Roadway Surfacing Selection Guide," Publication No. FHWA-CFL/TD-05-004.

Marquart, Mike. 2004. "Experimental Study ND 2002-01, “Base Reinforcement Using Geogrid” Construction Report." North Dakota DOT Materials and Research Division. http://www.dot.nd.gov/divisions/materials/research_project/nd0201report.pdf [accessed 1/9/2015]

Perkins, Steven W. 1995. *Feasibility of the Use of Existing Analytical Models and Experimental Data to Assess Current Design Methods for Pavement Geogrid-Reinforced Base Layers*, Montana State University, Bozeman.

———. 1999. *Geosynthetic Reinforcement of Flexible Pavements: Laboratory Based Pavement Test Sections*, Montana State University, Bozeman.

———. 2001. *Numerical Modeling of Geosynthetic Reinforced Flexible Pavements*, Montana State University, Bozeman.

———. 2002. *Evaluation of Geosynthetic Reinforced Flexible Pavement Systems Using Two Pavement Test Facilities,* Western Transportation Institute, Montana State University, Bozeman.

Prozzi, J., Stokoe, K. 2007. "Quantify the Benefits of Using Geosynthetics for Unbound Base Courses." Texas Department of Transportation. http://ftp.dot.state.tx.us/pub/txdot-info/rti/psr/4829.pdf accessed 1/8/2014

Prozzi, J., Thompson, N. 2009. "Development of Application Guide and Specifications for Geotextiles in Soil and Base." Texas Department of Transportation. http://ftp.dot.state.tx.us/pub/txdot-info/rti/psr/5812.pdf accessed 1/8/2014

Richardson, G.N. 1998. "Geosynthetics in Pavement Systems Applications, Section One: Geogrids, Section Two: Geotextiles." (GMA White Paper I), prepared for AASHTO, Geosynthetics Materials Association, Roseville, MN.

Steward, J., Williamson, R. and Mohney, J. 1977. "Guidelines for Use of Fabrics in Construction and Maintenance of Low-Volume Roads.” USDA, Forest Service, Portland, OR. Also reprinted as Report No. FHWA-TS-78-205.

Suits, L. D., Richardson, G. N. 1998. “M288-96: The Updated AASHTO Geotextile Specifications.” In: *Geotechnical Fabrics Report* 16 (2): 39-43, Industrial Fabrics Association International.

Tingle, J. and Jersey, S. 2007. "Empirical Design Methods for Geosynthetic-Reinforced Low Volume Roads," Transportation Research Record, Journal of the Transportation Research Board, No. 1989, Low-Volume Roads 2007, Volume 2.

Tingle, J. and Webster, S. 2003. "Review of Corps of Engineers Design of Geosynthetic Reinforced Unpaved Roads." *Transportation Research Record, TRB 2003 Annual Meeting.*

US Army Corps of Engineers (USACE). 1977, "Civil Works Construction Guide. Specifications for Plastic Filter Fabrics." Specification No. CW-02215. Office, Chief of Engineers. Washington, DC.

———. 2003. "Use of Geogrids in Pavement Construction." Technical Letter No. 1110-1-189. http://www.geotechnicalinfo.com/usace_use_of_geogrids_in_pavement_construction.pdf [accessed 1/9/2015]

US Department of the Army, US Department of the Air Force. 1995. "Engineering Use of Geotextiles" Technical manual TM 5-818-8.

Webster, S. L. 1993. "Geogrid Reinforced Base Courses for Flexible Pavements for Light Aircraft: Test Section Construction, Behavior under Traffic, Laboratory Tests, and Design Criteria." Technical Report GL-93-6, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Zornberg, J.G. 2012. "Geosynthetic-Reinforced Pavement Systems." 5th European Geosynthetics Congress, Valencia, Spain.

Zornberg, J.G. and Gupta, R., 2010. "Geosynthetics in Pavements: North American Contributions." University of Texas at Austin. 9th International Conference on Geosynthetics, Brazil.

APPENDIX A: SURVEY FORM

Geosynthetics Research Project – Survey

Agency:
Name and title of responder:
Responder email:
Responder telephone(s):
Date:

1. **Please provide an Internet link or other source for your agency's specifications related to geosynthetics.**

2. **Please provide an Internet link or other source for your agency's list of approved geosynthetic products.**

3. **What types of geosynthetic materials are typically used by your agency for pavement system base reinforcement?**

4. **What types of geosynthetic materials are typically used by your agency for pavement system subgrade stabilization?**

5. **When are geogrids used?**

6. **When are geotextile fabrics used with geogrids for separation?**

7. **Has your agency conducted research or performance testing on geogrids? If so, please provide a description of the research and Internet links to any available reports.**

APPENDIX B: INTERNET LINKS TO DOT GEOSYNTHETIC SPECIFICATIONS

Table B-1. Internet Links to DOT Geosynthetic Specifications

US State:	Abbre-viation:	DOT Specifications Links:
Alabama	AL	Alabama Department of Transportation Section 810 Geotextiles http://www.dot.state.al.us/conweb/doc/Specifications/2012%20DRAFT%20Standard%20Specs.pdf [8/5/13]
Alaska	AK	Alaska Department of Transportation and Public Facilities Section 729 Geosynthetics http://www.dot.state.ak.us/stwddes/dcsspecs/assets/pdf/hwyspecs/2004sshc.pdf [8/5/13]
Arizona	AZ	Arizona Department of Transportation Section 1014 Geosynthetics http://www.azdot.gov/business/ContractsandSpecifications/Specifications [8/5/13]
Arkansas	AR	Arkansas State Highway and Transportation Department Section 625 Geotextile Fabric http://www.arkansashighways.com/standard_spec/2003/03-600.pdf [8/9/13]
California	CA	California Department of Transportation – CALTRANS Section 88 Geosynthetic http://www.dot.ca.gov/hq/esc/oe/construction_contract_standards/std_specs/2010_StdSpecs/2010_StdSpecs.pdf Section 88 Geosynthetic Special Provision http://www.dot.ca.gov/hq/esc/oe/construction_contract_standards/SSPs/2010-SSPs/_rss/RSS_A07-19-13.docx [8/9/13]
Colorado	CO	Colorado Department of Transportation Section 712 Miscellaneous Subsection 712.08 Geotextiles Subsection 712.12 Geocomposite Drains http://www.coloradodot.info/business/designsupport/construction-specifications/2011-Specs/2011-specs-book/2011-Specs-Book.pdf/view [9/10/13]
Connecticut	CT	Connecticut Department of Transportation Form 815, Division II Construction Details, Section 2.19 Sedimentation Control System (Silt Fence) Form 815, Division II Incidental Construction, Section 7.51 Underdrain and Outlets Form 815, Division II Incidental Construction, Section 7.55 Geotextile Form 815, Division III, Materials, Section M.08 Drainage, 26-Geotextile http://www.ct.gov/dot/cwp/view.asp?a=1385&Q=259498&dotPNavCtr=|#40007 [8/9/13]

Table B-1. Internet Links to DOT Geosynthetic Specifications (Continued)

US State:	Abbre-viation:	DOT Specifications Links:
Delaware	DE	Delaware Department of Transportation Section 713 Geotextiles Section 715 Perforated Pipe Underdrains Section 827 Geotextile (Silt Fence) http://www.deldot.gov/information/pubs_forms/manuals/standard_specifications/pdf/2001StdSpecForRoadAndBridgeConstruction.pdf May 6, 2013 Supplemental Specifications http://www.deldot.gov/information/pubs_forms/manuals/standard_specifications/pdf/supplemental/supplemental_specifications_2013-05-06.pdf [8/9/13]
Florida	FL	Florida Department of Transportation Section 985 Geotextile Fabrics http://www.dot.state.fl.us/specificationsoffice/Implemented/SpecBooks/default.shtm Design Standards, Index No. 199 – Physical Requirements http://www.dot.state.fl.us/rddesign/DS/10/IDx/199.pdf [9/10/13]
Georgia	GA	Georgia Department of Transportation Section 809 Geogrid Materials Section 881 Fabrics http://www.dot.ga.gov/doingbusiness/TheSource/specs/DOT2013.pdf [8/12/13]
Hawaii	HI	Hawaii Department of Transportation Section 313 Permeable Separator Section 646 Geocomposite Drain Section 716 Geotextiles http://hidot.hawaii.gov/highways/s2005-standard-specifications/2005-standard-specifications/ [8/12/13]
Idaho	ID	Idaho Transportation Department Section 640 Construction Geotextiles Section 718 Geotextiles http://www.itd.idaho.gov/manuals/Manual%20Production/SpecBook/SpecHome.htm [8/12/13]
Illinois	IL	Illinois Department of Transportation Section 282 Filter Fabric Section 1040 Filter Fabric Drain Pipe, Tile, Drainage Mat, and Wall Drain Section 1080 Fabric Materials http://www.dot.state.il.us/desenv/stdspecs12.html [8/12/13]

Table B-1. Internet Links to DOT Geosynthetic Specifications (Continued)

US State:	Abbre-viation:	DOT Specifications Links:
Indiana	IN	Indiana Department of Transportation Section 205 Temporary Erosion and Sediment Control Section 214 Geogrid Section 918 Soil Fabrics http://www.in.gov/dot/div/contracts/standards/book/sep13/sep.htm [8/12/13]
Iowa	IA	Iowa Department of Transportation Section 4196 Engineering Fabrics http://www.google.com/url?sa=t&rct=j&q=iowa%20dot%20standard%20specifications&source=web&cd=5&cad=rja&ved=0CEkQFjAE&url=http%3A%2F%2Fwww.iowadot.gov%2Fspecifications%2FSpecificationsseries2012.pdf&ei=eUMvUqi2C6jgiAKl5YHwBg&usg=AFQjCNEMfU7BM0mEqJQHoRrGIlrfMlGNHg&bvm=bv.51773540,d.cGE [8/12/13]
Kansas	KS	Kansas Department of Transportation Section 1706 Abutment Strip Drain Section 1710 Geotextile Fabric Special Provision 07-17004 Geosynthetics http://www.ksdot.org/burconsmain/specprov/2007SSDefault.asp [8/12/13]
Kentucky	KY	Kentucky Transportation Cabinet Section 214 Geotextile Construction Section 843 Geotextile Fabrics Section 845 Fabric Wrapped Backfill Drain Materials http://transportation.ky.gov/Construction/Standard%20amd%20Supplemental%20Specifications/Complete%20KYTC%20Standard%20Specifications-2012.pdf Geogrid Reinforcement for Asphalt Pavements http://transportation.ky.gov/Construction/Special%20Notes%20and%20Special%20Provisions/SPECIAL%20NOTE%2011I%20GEOGRID%20REINFORCEMENT%20FOR%20ASPHALT%20PAVEMENTS.doc [8/12/13]
Louisiana	LA	Louisiana Department of Transportation and Development Subsection 203.11 Geotextile Fabrics Subsection 204 Temporary Erosion Control http://www.dotd.la.gov/highways/specifications/documents/2006%20Standard%20Specifications%20for%20Roads%20and%20Bridges%20Manual/06%20-%202006%20-%20Part%20II%20-%20Earthwork.pdf Section 1019 Geotextile Fabric and Geocomposite Systems http://www.dotd.la.gov/highways/specifications/documents/2006%20Standard%20Specifications%20for%20Roads%20and%20Bridges%20Manual/14%20-%202006%20-%20Part%20X%20-%20Materials.pdf [8/26/13]
Maine	ME	Maine Department of Transportation Section 620 Geotextiles http://maine.gov/mdot/contractors/publications/standardspec/docs/ss_combined.pdf http://www.maine.gov/tools/whatsnew/attach.php?id=492579&an=1 [8/26/13]

Table B-1. Internet Links to DOT Geosynthetic Specifications (Continued)

US State:	Abbre-viation:	DOT Specifications Links:
Maryland	MD	Maryland Department of Transportation Section 211 Geosynthetic Stabilized Subgrade Using Graded Aggregate Base Section 306 Underdrains, Subgrade Drains, and Spring Control Section 308 Erosion and Sediment Control Subsection 921.09 Geotextiles http://roads.maryland.gov/ohd/frontpage.pdf [8/26/13]
Massachusetts	MA	Massachusetts Department of Transportation Materials Subsection M9.50.0 Geotextile Fabrics – AASHTO M288 http://www.mhd.state.ma.us/default.asp?pgid=content/88specs&sid=about http://www.massdot.state.ma.us/Portals/8/docs/construction/SupplementalSpecs20120615.pdf http://www.massdot.state.ma.us/Portals/8/docs/construction/InterimSuppSpecs.pdf [8/26/13]
Michigan	MI	Michigan Department of Transportation Section 308 Geotextiles For Base Section 910 Geosynthetics http://mdotcf.state.mi.us/public/specbook/2012 [8/26/13]
Minnesota	MN	Minnesota Department of Transportation Section 3733 Geotextiles refers to: 2014 Materials Lab Supplemental Specifications for Construction Division III Materials 3733 Geotextiles http://www.dot.state.mn.us/pre-letting/spec/2014/2014-Std-Spec-for-Construction.pdf http://www.dot.state.mn.us/pre-letting/spec/2014/2014-Materials-Lab-Supplement.pdf [8/26/13]
Mississippi	MS	Mississippi Department of Transportation Section 204 Geogrid Reinforcement of Embankment Slopes and Subgrades Section 209 Geotextile Stabilization Subsection 714.13 Geotextiles Subsection 714.14 Geotextile for Moisture Barrier Subsection 714.15 Geogrids Section 809 Retaining Wall Systems http://mdot.ms.gov/documents/construction/Standard%20Specifications/Entire%20Book%20-%205.6%20MB.pdf [8/26/13]
Missouri	MO	Missouri Department of Transportation Subsection 605.20 Geocomposite Pavement Edge Drain Section 624 Geotextile Construction Section 1011 Geotextile Section 1012 Geocomposite Drainage Material http://www.modot.org/business/standards_and_specs/BEGIN.pdf [8/26/13]

Table B-1. Internet Links to DOT Geosynthetic Specifications (Continued)

US State:	Abbre-viation:	DOT Specifications Links:
Montana	MT	Montana Department of Transportation Section 622 Geotextiles (Installation) Section 716 Geotextiles (Materials Specification) http://www.mdt.mt.gov/other/contract/external/standard_specbook/2006/2006_stand_specs.pdf [8/26/13]
Nebraska	NE	Nebraska Department of Roads (NDR) **No specification** – Refers to geotextiles on NDR Approved Products List http://www.transportation.nebraska.gov/ref-man/specbook-2007.pdf [8/26/13]
Nevada	NV	Nevada Department of Transportation **No specification for geotextiles or geosynthetics** http://www.nevadadot.com/uploadedFiles/NDOT/About_NDOT/NDOT_Divisions/Engineering/Specifications/2001StandardSpecifications.pdf [8/26/13]
New Hampshire	NH	New Hampshire Department of Transportation Section 593 Geotextile Bureau of Materials Research Qualification Criteria http://www.nh.gov/dot/org/projectdevelopment/highwaydesign/specifications/index.htm http://www.nh.gov/dot/org/projectdevelopment/materials/research/documents/pqc593-geotextile.pdf [8/26/13]
New Jersey	NJ	New Jersey Department of Transportation Subsection 919.01 Geotextiles Subsection 919.05 Geomembrane Liner http://www.state.nj.us/transportation/eng/specs/2007/spec900.shtm#s919 [8/26/13]
New Mexico	NM	New Mexico Department of Transportation Section 604 Soil and Drainage Geotextiles http://dot.state.nm.us/content/dam/nmdot/Plans_Specs_Estimates/2007_Specs_for_Highway_and_Bridge_Construction.pdf [8/26/13]
New York	NY	New York State Department of Transportation Section 554 Fill Type Retaining Walls Section 737 Geosynthetics https://www.dot.ny.gov/main/business-center/engineering/specifications/english-spec-repository/espec9-5-13english.pdf [9/10/13]
North Carolina	NC	North Carolina Department of Transportation Section 270 Geotextile for Soil Stabilization Section 275 Rock Plating Section 1056 Geosynthetics https://connect.ncdot.gov/resources/Specifications/Pages/Specifications-and-Special-Provisions.aspx [9/10/13]

Table B-1. Internet Links to DOT Geosynthetic Specifications (Continued)

US State:	Abbre-viation:	DOT Specifications Links:
North Dakota	ND	North Dakota Department of Transportation Section 708 Erosion Control Section 709 Geotextile Fabrics (Installation) Section 858 Geotextile Fabrics (Material Requirements) http://www.dot.nd.gov/manuals/environmental/2008-Vol01.pdf [9/10/13]
Ohio	OH	Ohio Department of Transportation Section 204 Subgrade Compaction and Proof Rolling Subsection 712.09 Geotextile Fabrics Subsection 712.10 Prefabricated Edge Underdrain Subsection 712.11 http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Specifications/2010CMS/2010%20CMS%20Final%2012222009%20.pdf Supplemental Specification 861 Geogrid for Subgrade Stabilization http://www.dot.state.oh.us/Divisions/ConstructionMgt/Specification%20Files/861_07192013_for_2013.pdf [9/10/13]
Oklahoma	OK	Oklahoma Department of Transportation Section 325 Separator Fabric for Bases Section 326 Geosynthetic Reinforcement Section 712 Construction Fabrics http://www.okladot.state.ok.us/c_manuals/specbook/oe_ss_2009.pdf [9/10/13]
Oregon	OR	Oregon Department of Transportation Subsection 00331.41 Geotextile Section 00350 Geosynthetic Installation Section 00430 Subsurface Drains Section 00435 Prefabricated Vertical Drains Subsection 00641.42 Placing Aggregate Base or Subbase on Geotextile Section 02320 Geosynthetics http://www.oregon.gov/ODOT/HWY/SPECS/Pages/standard_specifications.aspx#2008_Standard_Specifications Section 02320 Geosynthetics Special Provision http://www.oregon.gov/ODOT/HWY/SPECS/docs/08specials/updates/_2012/06-07-12/sp2320.pdf Unique 00350 Subgrade Reinforcement Geogrid http://www.oregon.gov/ODOT/HWY/SPECS/docs/unique/u00350-subgrade-reinforcement-geogrid.doc [9/11/13]
Pennsylvania	PA	Pennsylvania Department of Transportation Section 735 Geotextiles ftp://ftp.dot.state.pa.us/public/pdf/Pub408Change4/Section700/Section735.pdf [9/25/13]

Table B-1. Internet Links to DOT Geosynthetic Specifications (Continued)

US State:	Abbre-viation:	DOT Specifications Links:
Rhode Island	RI	Rhode Island Department of Transportation No specification. Uses Approved Materials List Per AASHTO M288 for Geotextiles, Geogrids, Paving Fabrics, Filter Fabric – Landscape http://www.dot.ri.gov/documents/engineering/BlueBook/Bluebook_2010.pdf http://www.dot.ri.gov/documents/engineering/research/approvals/RIDOTApprovedProducts.pdf [9/25/13]
South Carolina	SC	South Carolina Department of Transportation Subsection 804.2.7.5 Geotextile Fabric Subsection 804.2.11 Geotextile for Erosion Control Under Riprap Subsection 804.4.6 Geotextile Fabric for Slope Protection Subsection 815.2.5.2 http://www.scdot.org/doing/doingPDFs/2007_full_specbook.pdf Geotextile for Drainage Filtration Supplemental Specification http://www.scdot.org/doing/technicalPDFs/supSpecs/91-10-15.pdf Geotextile For Separation of Subgrade and Subbase or Base Course Materials Supplemental Specification http://www.scdot.org/doing/technicalPDFs/supSpecs/92-03-16.pdf [9/25/13]
South Dakota	SD	South Dakota Department of Transportation Section 430 Bridge End Backfill (Installation) Section 831 Geotextile and Impermeable Plastic Membrane http://www.sddot.com/business/contractors/specs/SDDOTStandardSpecifications2004.pdf [9/26/13]
Tennessee	TN	Tennessee Department of Transportation Section 740 Geotextiles Subsection 918.27 Geotextile Material http://www.tdot.state.tn.us/construction/specbook/2006_Spec700.pdf http://www.tdot.state.tn.us/construction/specbook/2006_Spec900.pdf Supplemental Specifications – Section 900, Subsection 918.27 Geotextile http://www.tdot.state.tn.us/construction/Supplemental%20Specs%202006/SS900.pdf [9/26/13]

Table B-1. Internet Links to DOT Geosynthetic Specifications (Continued)

US State:	Abbre-viation:	DOT Specifications Links:
Texas	TX	Texas Department of Transportation Texas Materials Specifications DMS 6200 Filter Fabric DMS 6210 Vertical Moisture Barrier DMS 6220 Fabric for Underseals DMS 6230 Temporary Sediment Control Fence DMS 6240 Geogrid for Base/Embankment Reinforcement DMS 6250 Geogrid Fabric Composite for Pavements DMS 6260 Reinforced Fabric Joint Underseal DMS 6270 Biaxial Geogrid for Environmental Cracking http://www.txdot.gov/business/resources/dms.html?CFC__target=http%3A%2F%2Fwww.dot.state.tx.us%2Fapps-cg%2Fmaterial_specifications%2Fdms_series.htm%3Fseries%3D6000 [9/27/13]
Utah	UT	Utah Department of Transportation Section 01571 Temporary Environmental Controls Section 02075 Geotextiles http://www.udot.utah.gov/main/uconowner.gf?n=7569028183854784 Supplemental Specifications Section 02072S Geogrid Subgrade Stabilization Section 02073S Geogrid Base Reduction http://www.udot.utah.gov/main/uconowner.gf?n=11273407293344224 https://www.google.com/url?q=http://www.udot.utah.gov/main/uconowner.gf%3Fn%3D10095731736964093&sa=U&ei=jNFFUpaxApCJiwK5zoDgCw&ved=0CAcQFjAA&client=internal-uds-cse&usg=AFQjCNGmvYOsdBBl991o0FyIIDMGUdu1FQ [9/27/13]
Vermont	VT	Vermont Agency of Transportation Section 649 Geotextile Fabric (Installation) Section 720 Geotextiles (Physical Requirements) http://vtranscontracts.vermont.gov/sites/aot_contract_administration/files/documents/2011specbook/2011Division600.pdf http://vtranscontracts.vermont.gov/sites/aot_contract_administration/files/documents/2011specbook/2011Division700.pdf [9/27/13]
Virginia	VA	Virginia Department of Transportation Section 245 http://www.virginiadot.org/business/resources/const/2007SpecBook.pdf SS4503 Supplemental Section 245 4-30-13 http://www.virginiadot.org/business/resources/const/07RevDiv_II.pdf [9/27/13]
Washington	WA	Washington Department of Transportation Section 2-12 Construction Geosynthetic (Installation) Section 6-13 Structural Earth Walls Section 6-14 Geosynthetic Retaining Walls Section 9-33 Construction Geosynthetic (Physical Requirements) http://www.wsdot.wa.gov/publications/manuals/fulltext/M41-10/SS2012.pdf [9/30/13]

Table B-1. Internet Links to DOT Geosynthetic Specifications (Continued)

US State:	Abbre-viation:	DOT Specifications Links:
West Virginia	WV	West Virginia Department of Transportation Section 206 Base Course Reinforcement Geogrid http://www.transportation.wv.gov/highways/contractadmin/specifications/Documents/2010%20Standard%20Specifications%20Roads%20and%20Bridges/Complete%20Publications/2010StandardRoadsnBridges.pdf 2013 Supplemental Specifications Subsection 715-10 Prefabricated Drainage System Subsection 715-11 Engineering Fabric http://www.transportation.wv.gov/highways/contractadmin/specifications/2013Supp/Documents/20130102_rs_2013%20Supplemental%20Specifications.pdf [9/30/13]
Wisconsin	WI	Wisconsin Department of Transportation Section 645 Geotextile Fabrics http://roadwaystandards.dot.wi.gov/standards/stndspec/index.htm [11/19/13]
Wyoming	WY	Wyoming Department of Transportation Section 217 Geotextiles (Installation) Section 805 Geotextiles, Membrane, and Fabrics http://www.dot.state.wy.us/home/engineering_technical_programs/manuals_publications/2010_Standard_Specifications.html [11/19/13]

APPENDIX C: INTERNET LINKS TO APPROVED/QUALIFIED GEOSYNTHETICS PRODUCTS LIST

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists

US State:	Abbre-viation:	APL/QPL Link:
Alabama	AL	Alabama Department of Transportation Geotextiles: http://www.dot.state.al.us/mtweb/Testing/MSDSAR/doc/QMSD/Lii03.pdf [9/12/2013]
Alaska	AK	Alaska Department of Transportation and Public Facilities QPL: http://www.dot.alaska.gov/stwddes/desmaterials/qpl_intro.shtml [9/12/2013]
Arizona	AZ	Arizona Department of Transportation APL: http://www.azdot.gov/docs/default-source/approved-products/apl201309.pdf?sfvrsn=2 [9/12/2013]
Arkansas	AR	Arkansas State Highway and Transportation Department Main link: http://www.arkansashighways.com/materials_division/materials.aspx [9/12/2013] QPL: Geotextiles: http://www.arkansashighways.com/materials_division/Division%20600%20Incidental%20Construction/625%20Geotextile%20Fabric.pdf [9/12/2013]
California	CA	California Department of Transportation Pre-approved Alternative Earth Retaining Systems http://www.dot.ca.gov/hq/esc/approved_products_list/pdf/earth_retaining_syst.pdf [10/5/2013]
Colorado	CO	Colorado Department of Transportation www.coloradodot.info Not available online
Connecticut	CT	Connecticut Department of Transportation QPL: http://www.ct.gov/dot/lib/dot/documents/dresearch/conndot_qpl.pdf [9/12/2013]
Delaware	DE	Delaware Department of Transportation Ref: http://deldot.gov/information/business/prodlists/new_product_eval/index.shtml [9/12/2013] "The Delaware Department of Transportation (DelDOT) does not maintain an approved/qualified products list for most construction products (other than stormwater items managed by our Stormwater Section)."

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
Florida	FL	Florida Department of Transportation QPL Index: http://www.dot.state.fl.us/SpecificationsOffice/ProductEvaluation/QPL/QPLIndex.shtm [9/12/2013] Geotextiles that are approved for reinforcement are included in our Standards http://www.dot.state.fl.us/rddesign/DS/14/IDx/00501.pdf Geotextiles for drainage must meet specified properties. Project personnel provide a copy of test results from the geotextile manufacture which is evaluated to ensure these materials meet the requirements. http://www.dot.state.fl.us/rddesign/DS/14/IDx/00199.pdf Retaining walls: http://www2.dot.state.fl.us/SpecificationsEstimates/ProductEvaluation/QPL/QPLItems.aspx?QPLTitle=Specification 548 Retaining Wall Systems&QPLDesc=Retaining Wall System&QPLNum=S548 [10/5/2013]
Georgia	GA	Georgia Department of Transportation QPL Index: http://www.dot.ga.gov/doingbusiness/Materials/qpl/Pages/Category.aspx [9/12/2013] Silt Fences: http://www.dot.ga.gov/doingbusiness/Materials/qpl/Documents/qpl36.pdf [9/12/2013] Soil Reinforcing Mats: http://www.dot.ga.gov/doingbusiness/Materials/qpl/Documents/qpl49.pdf [9/12/2013] Filter Fabrics: http://www.dot.ga.gov/doingbusiness/Materials/qpl/Documents/qpl28.pdf [9/12/2013] Geocomposite Wall Drains: http://www.dot.ga.gov/doingbusiness/Materials/qpl/Documents/qpl47.pdf [9/12/2013] Waterproofing Membranes: http://www.dot.ga.gov/doingbusiness/Materials/qpl/Documents/qpl22.pdf [9/12/2013]
Hawaii	HI	Hawaii Department of Transportation None found
Idaho	ID	Idaho Transportation Department QPL Search: http://apps.itd.idaho.gov/apps/materials/SearchByCat.aspx [9/12/2013]

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
Illinois	IL	Illinois Department of Transportation Products Evaluation Circular: http://www.dot.il.gov/materials/research/newprodsevalcircular.pdf [9/12/2013]
Indiana	IN	Indiana Department of Transportation None found
Iowa	IA	Iowa Department of Transportation References CalTrans Qualified Products List for bids APPROVED SOURCES ENGINEERING FABRICS SUB-GRADE STABILIZATION POLYMER GRID http://www.iowadot.gov/erl/current/IM/content/496.01ae.htm [9/25/2013] APPROVED SOURCES ENGINEERING FABRICS GEO TEXTILE FOR ABUTMENT BACKFILL http://www.iowadot.gov/erl/current/IM/content/496.01ag.htm [9/25/2013]
Kansas	KS	Kansas Department of Transportation Pre-Qualified Materials List: http://www.ksdot.org/burmatrres/pql/default.asp [9/13/2013] Geotextile Fabrics: http://www.ksdot.org/burmatrres/pql/pql-48-0.pdf [9/13/2013]
Kentucky	KY	Kentucky Transportation Cabinet List of Approved Materials: http://transportation.ky.gov/Materials/Documents/LAM.PDF [9/13/2013]
Louisiana	LA	Louisiana Department of Transportation and Development Qualified Products List Manual: http://www.dotd.la.gov/highways/construction/lab/qpl/tableofcontents.shtml [9/13/2013] Geotextile Fabrics: http://www.dotd.la.gov/highways/construction/lab/qpl/qpl%2061%20geotextile%20fabrics.pdf [9/13/2013] Geocomposite Drainage Systems: http://www.dotd.la.gov/highways/construction/lab/qpl/qpl%2062%20geocomposite%20drainage%20systems.pdf [9/13/2013]
Maine	ME	Maine Department of Transportation Qualified Products List: http://www.maine.gov/mdot/tr/qpl/ [9/13/2013]
Maryland	MD	Maryland Department of Transportation Lists of Qualified Products: http://roads.maryland.gov/OMT/geosynthetic.pdf [9/25/2013] MSM 732: All Geotextile materials shall be listed in the National Transportation Product Evaluation Program (NTPEP) for geotextile products.

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
Massachusetts	MA	Massachusetts Department of Transportation Qualified Construction Materials List: http://www.mhd.state.ma.us/default.asp?pgid=research_materials/materials01&sid=about [9/13/2013] Geotextile Fabrics: http://www.mhd.state.ma.us/default.asp?pgid=research_materials/materials03i&sid=about [9/13/2013]
Michigan	MI	Michigan Department of Transportation Qualified Products List: http://www.michigan.gov/documents/MDOT-Material_Source_Guide_Qualified_Products_84764_7.pdf [9/13/2013]
Minnesota	MN	Minnesota Department of Transportation Approved/Qualified Products: http://www.dot.state.mn.us/products/index.html [9/13/2013] Geosynthetic Products: http://www.dot.state.mn.us/products/geosynthetics/index.html [9/13/2013] Adhesive Seams: http://www.dot.state.mn.us/products/geosynthetics/adhesiveseams.html [9/13/2013] Erosion Control and Landscaping Products: http://www.dot.state.mn.us/products/erosioncontrolandlandscaping/index.html [9/13/2013] Geotextile for Silt Fence Application: http://www.dot.state.mn.us/products/erosioncontrolandlandscaping/geotextileforsiltfenceapplications.html [9/13/2013]
Mississippi	MS	Mississippi Department of Transportation [11/1/2013] Approved Products: http://sp.mdot.ms.gov/Materials/Pages/Product-Category.aspx Geogrids, Type I Geogrids, Type II Geogrids, Type III Geogrids, Type IV Geogrids, Type V Geogrids, Type VI
Missouri	MO	Missouri Department of Transportation [11/1/2013] GEOTEXTILE FIELD, PRE-QUALIFIED GEOSYNTHETIC MATERIAL http://www.modot.org/business/materials/pdf/vol_1/FS1011T2.pdf GEOTEXTILE FIELD, PRE-QUALIFIED GEOSYNTHETIC MATERIAL UNBONDED CONCRETE OVERLAY INTERLAYER http://www.modot.org/business/materials/pdf/vol_1/FS1011T3.pdf

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
Montana – PART 1	MT	Montana Department of Transportation [9/25/2013] QPL Main Page http://www3.mdt.mt.gov:7782/mttplc/mtstm.stmk0009.QPL_INIT Geotextile Separation High Survivability http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.02.00.01 Geotextile Separation Mod Survivability http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.02.00.02 Geotextile Stabilization – High http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.03.00.01 Geotextile Stabilization – Moderate http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.03.00.02 Geotextile Sub Drain Class A-High Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.04.00.01 Geotextile Sub Drain Class B-High Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.04.00.02 Geotextile Sub Drain Class C-High Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.04.00.03 Geotextile Sub Drain Class A-Mod Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.04.00.04 Geotextile Sub Drain Class B-Mod Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.04.00.05 Geotextile Sub Drain Class C-Mod Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.04.00.06

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
Montana – PART 2	MT	Geotex Perm Ero Cntl Class A-High Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.05.00.01 Geotex Perm Ero Cntl Class B-High Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.05.00.02 Geotex Perm Ero Cntl Class C-High Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.05.00.03 Geotex Perm Ero Cntl Class A-Mod Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.05.00.04 Geotex Perm Ero Cntl Class B-Mod Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.05.00.05 Geotex Perm Ero Cntl Class C-Mod Surv http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.05.00.06 Geotextile Stabilized Silt Fence http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.06.00.01 Geotextile Unstabilized Silt Fence http://www3.mdt.mt.gov:7782/mttplc/MTSTM.STMK0009.EXT_QPL_LIST?CNAME=&CMTRL=716.06.00.02
Nebraska	NE	Nebraska Department of Roads APL http://www.transportation.nebraska.gov/mat-n-tests/pdfs-docs/APL_PDF_9-24-2013.pdf [9/26/2013]
Nevada	NV	Nevada Department of Transportation None found
New Hampshire	NH	New Hampshire Department of Transportation QPL http://www.nh.gov/dot/org/projectdevelopment/materials/research/documents/qpl.pdf [9/26/2013]

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
New Jersey	NJ	New Jersey Department of Transportation [10/8/2013] New Technologies Qualified Products http://www.state.nj.us/transportation/eng/technology/NTPDB_category.shtm Select: • Geotextiles • Pavement Reinforcement Geogrid
New Mexico	NM	New Mexico Department of Transportation APL by Spec # http://www.dot.state.nm.us/content/dam/nmdot/APL/APL.pdf [9/26/2013]
New York	NY	New York State Department of Transportation [9/26/2013] APL https://www.dot.ny.gov/divisions/engineering/technical-services/materials-bureau/materials-and-equipment Geosynthetics https://www.dot.ny.gov/divisions/engineering/technical-services/technical-services-repository/alme/geo.html
North Carolina	NC	North Carolina Department of Transportation [9/26/2013] Geotechnical Approved Lists https://connect.ncdot.gov/resources/Geological/Pages/Products.aspx Geotextiles https://apps.dot.state.nc.us/vendor/approvedproducts/Default.aspx
North Dakota	ND	North Dakota Department of Transportation Does not maintain an Approved Products List for construction related materials. https://www.dot.nd.gov/divisions/materials/approvedproducts.htm [9/26/2013]
Ohio	OH	Ohio Department of Transportation [10/8/2013] QPL http://www.dot.state.oh.us/Divisions/ConstructionMgt/Materials/Pages/QPL.aspx Geotextiles http://www.odotonline.org/materialsmanagement/qpl.asp?specref=712.09 Geogrids http://www.odotonline.org/materialsmanagement/qpl.asp?specref=SS861

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
Oklahoma	OK	Oklahoma Department of Transportation [10/2/2013] QPL http://www.okladot.state.ok.us/traffic/qpl/ No geosynthetic products found
Oregon	OR	Oregon Department of Transportation QPL http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/qpl/docs/qpl.pdf [9/26/2013]
Pennsylvania	PA	Pennsylvania Department of Transportation Bulletin 15 – Approved Construction Materials ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_35/BULLETIN_15.pdf ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_35/Bulletin15.pdf [9/26/2013]
Rhode Island	RI	Rhode Island Approved Materials List http://www.dot.ri.gov/documents/engineering/research/approvals/RIDOTApprovedProducts.pdf [9/26/2013]
South Carolina	SC	[9/26/2013] QPL Table of Contents http://www.scdot.org/doing/materials_qualified.aspx and http://www.scdot.org/doing/technicalPDFs/materialsResearch/qualifiedProducts/QPL-QPP-ToC.pdf QPL-34 QUALIFIED SILT FENCE GEOTEXTILE FABRICS http://www.scdot.org/doing/technicalPDFs/materialsResearch/qualifiedProducts/34%20QPL%20051811.pdf QPL-44 QUALIFIED PRODUCTS POLICY FOR GEOTEXTILE FOR SLOPE PROTECTION http://www.scdot.org/doing/technicalPDFs/materialsResearch/qualifiedProducts/44%20QPL.pdf

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
South Dakota	SD	[10/10/2013] APL Search page: http://apps.sd.gov/applications/HC60ApprovedProducts/main.aspx List: http://apps.sd.gov/applications/HC60ApprovedProducts/ProductList.aspx?Type=ApprovedProducts Geotextile Separator Fabric http://apps.sd.gov/applications/HC60ApprovedProducts/ProductList.aspx?Type=ProductTypeByID Silt Fence http://apps.sd.gov/applications/HC60ApprovedProducts/ProductList.aspx?Type=ProductTypeByID
Tennessee	TN	[10/10/2013] QPL http://www.tdot.state.tn.us/materials/reseval/docs/QPL.pdf QPL evaluation procedures http://www.tdot.state.tn.us/materials/reseval/docs/qualprodlist.pdf
Texas	TX	[10/1/2013] Material Producer List http://www.txdot.gov/inside-txdot/division/construction/producer-list.html Biaxial Geogrid for Environmental Cracking http://ftp.dot.state.tx.us/pub/txdot-info/cmd/mpl/geogrid.pdf Silt Fence, Filter Fabric, and Fabric Underseal http://ftp.dot.state.tx.us/pub/txdot-info/cmd/mpl/siltfnce.pdf
Utah	UT	[11/7/2013] Approved Products List http://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:239, No geosynthetic products listed
Vermont	VT	None found
Virginia	VA	Approved Geogrids/High-Strength Geotextiles http://www.virginiadot.org/business/resources/Materials/Approved_Lists.pdf [10/1/2013]
Washington	WA	[10/10/2013] QPL http://www.wsdot.wa.gov/Business/MaterialsLab/QPL.htm GEOSYNTHETIC RETAINING WALL http://www.wsdot.wa.gov/biz/mats/QPL/appendd.pdf

Table C-1. Internet Links to Approved/Qualified Geosynthetics Products Lists (Continued)

US State:	Abbre-viation:	APL/QPL Link:
West Virginia	WV	Geotextiles http://www.transportation.wv.gov/highways/mcst/Documents/APPROVED%20SOURCE%20LIST%20engineering%20fabric%202012-10.pdf [10/1/2013]
Wisconsin	WI	[10/1/2013] Pre-Qualified Product Lists http://www.dot.state.wi.us/business/engrserv/docs/ap1/approved-lists.pdf Product Acceptability List – Erosion Control Products http://www.dot.state.wi.us/business/engrserv/docs/pal.pdf
Wyoming	WY	None found
NTPEP		[10/10/2013] Geosynthetic and Geotextile Evaluation Reports http://www.ntpep.org/Pages/GeosyntheticsReports.aspx

APPENDIX D: SUMMARY OF STATE SURVEY RESPONSES

Table D-1. Types of Geosynthetic Materials Typically Used for Pavement System Base Reinforcement

<table>
<tr><th>State</th><th>Response</th></tr>
<tr><td>AL</td><td>List of materials provided–Internet link:
http://www.dot.state.al.us/mtweb/Testing/MSDSAR/doc/QMSD/Lii03.pdf</td></tr>
<tr><td>CA</td><td>Geotextile and Biaxial geogrids. See Section 88 in item 1 for subgrade enhancement geotextile and biaxial geogrid below:

88-1.02P Biaxial Geogrid

Geosynthetics used for biaxial geogrid must be a punched and drawn polypropylene material formed into an integrally formed biaxial grid. When tested under the referenced test methods, properties of biaxial geogrid must have the values shown in the following table:
Biaxial Geogrid
<table>
<tr><th>Property</th><th>Test</th><th>Value</th></tr>
<tr><td>Aperture size, inch[a]
min and max</td><td>Calipered</td><td>0.8-1.3 x 1.0-1.6</td></tr>
<tr><td>Rib thickness, inch
min</td><td>Calipered</td><td>0.04</td></tr>
<tr><td>Junction thickness, inch
min</td><td>Calipered</td><td>0.150</td></tr>
<tr><td>Tensile strength, 2% strain, lb/ft[a]
min</td><td>ASTM D 6637</td><td>410 x 620</td></tr>
<tr><td>Tensile strength at ultimate, lb/ft[a]
min</td><td>ASTM D 6637</td><td>1,310 x 1,970</td></tr>
<tr><td>Ultraviolet resistance, percent
min retained tensile strength, 500 hours</td><td>ASTM D 4355</td><td>100</td></tr>
<tr><td>Junction strength, lb/ft[a]
min</td><td>ASTM D 7737</td><td>1,220 x 1,830</td></tr>
<tr><td>Overall flexural rigidity, mg-cm
min</td><td>ASTM D 7748</td><td>750,000</td></tr>
<tr><td>Torsional rigidity at 20 cm-kg, mm-kg/deg[b]
min</td><td>GRI:GG9</td><td>0.65</td></tr>
</table>
[a]Machine direction x cross direction
[b]Geosynthetic Research Institute, Test Method GG9, Torsional Behavior of Bidirectional Geogrids When Subjected to In-Plane Rotation</td></tr>
<tr><td>CO</td><td>Geogrid.</td></tr>
<tr><td>CT</td><td>Not typically used.</td></tr>
<tr><td>DE</td><td>Typically, we use something meeting AASHTO M288 class 2 or better. It could be woven or non woven depending on the situation. We use woven when there aren’t concerns about clogging. Non woven is used where filtration is necessary.</td></tr>
<tr><td>FL</td><td>Provides a table of woven geotextile values, a table of woven geogrid values, and a table of extruded geogrid values in design standard 501 (http://www.dot.state.fl.us/rddesign/DS/14/IDx/00501.pdf)</td></tr>
<tr><td>GA</td><td>No geosynthetic materials are used for pavement system base reinforcement by GDOT.</td></tr>
<tr><td>ID</td><td>For pavement base reinforcement system, we often use biaxial geogrids.</td></tr>
<tr><td>IN</td><td>The Office of Geotechnical services recommend the geogrid for foundation improvements, subgrade and walls. Usually, base reinforcement is not used in INDOT.</td></tr>
<tr><td>IA</td><td>No response</td></tr>
<tr><td>KS</td><td>Although not in typical use, we have utilized geogrids for this application.</td></tr>
<tr><td>LA</td><td>We use fabrics meeting Class D in our specifications</td></tr>
</table>

Table D-1. Types of Geosynthetic Materials Typically Used for Pavement System Base Reinforcement
(Continued)

State	Response
ME	Geogrids.
MD	We are using Woven Geotextile meeting the requirement of AASHTO M288 and (attached 900-921 requirements). Very small quantity of Geogrid with 200 or 300 tensile strength are used for very specific application. Based on our limited field experiments, we found that the Geogrid used an insurance, not as a measure to reduce the thickness of base or HMA mix.
MI	The aggregate base layer is typically not reinforced. In the occasional instance when it is, a geogrid is used.
MN	Usually the aggregate base (when needed) has a geogrid. Some cases more due to underlying soft subsoils we have employed high-strength geotextiles and or geocells.
MO	Typically use biaxial geogrid. Starting to use Tensar Triax geogrid.
MT	We do not use geosynthetics in the pavement system, however, I believe there might have been a project or two where we have installed a separation geotextile below the base course.
NE	We don't typically use geosynthetics for base reinforcement.
NV	The geogrid shall be one of the following structure types: (A) A structure comprised of punched and drawn polypropylene (PP) or high-density polyethylene (HDPE) sheet integrally formed into a grid. (B) A structure comprised of high-density polyethylene (HDPE) or polypropylene (PP) extruded to form a grid.
NH	We don't typically use geosynthetic materials for this purpose although we have tried them on occasion.
NY	NYSDOT does not use geosynthetic materials for this application.
NC	Not used
ND	We don't typically used geosynthetic materials for base reinforcement we have however used geogrids occasionally in the base for reinforcement.
OR	None at this time. Here is a link to our Qualified Products List (QPL) webpage where we have our requirements (see Subgrade Reinforcement Geogrid): http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/Pages/qpl/QPIndex.aspx
PA	I don't think we do this. Kerry, any thoughts? No standards, however either a biaxial geogrid or woven geotextile is used in cases when called out by special provision. In cases where called out, it is usually called for at the subbase-subgrade interface – not generally within the subbase. For #3, "base reinforcement" refers to the use of lateral confinement to improve the load carrying capacity of the pavement system under repetitive traffic loadings. This would involve using a geosynthetic to reduce the structural section thickness and/or to improve the service life of the pavement by reducing rutting and cracking. The geosynthetic could be used at the bottom of the base or subbase or within the base course. For #4, "subgrade stabilization" refers to constructing platforms over weak subgrades and possibly high water tables to enable construction of a pavement system. This would involve using a geosynthetic in lieu of other methods of subgrade stabilization such as lime and cement treated subgrades, or over-excavation. The geosynthetic would be used at the subgrade/sub base interface or the subgrade/base interface to increase bearing capacity.

Table D-1. Types of Geosynthetic Materials Typically Used for Pavement System Base Reinforcement
(Continued)

State	Response
RI	Pavement bases are typically not reinforced. We occasionally use a Biaxial or Triaxial geogrid to reinforce pavement subbases and/or subgrades if problem areas are recognized. Again, typically designed by a consultant.
SC	We currently do not use geosynthetics for base reinforcement.
SD	We use geogrid when we place geosynthetic materials actually in the base, but this is very infrequent. We will use either grid or geotextile at the base-subgrade contact.
TX	These fall under DMS-6240 (Departmental Materials Specification-6240), There is no MPL (Material Producer List) available for these products.
UT	Bi-axial Geogrid
VA	pavement system base reinforcement? We do not use these much. We use drainage fabric or subgrade stabilization fabric for separation and wrapping stone replacement of unsuitable undercut. Geogrids have been used infrequently. We do not account for these in the pavement structure for design.

Table D-2. Types of Geosynthetic Materials Used for Subgrade Stabilization

State	Response
AL	We have used both geotextiles and geogrids for subgrade stabilization in areas where we have encountered soft soils. Please see Section 243 of our Standard Specifications referenced in number 1 above.
CA	Geotextiles and biaxial geogrids are used for subgrade stabilization. All geosynthetics meeting the specifications in above items 1 and 3 may be used.
CO	Geotextile and geogrid.
CT	Not typically used, very few areas where weak subgrade soils are encountered.
DE	Common practice is to pick a class 2 or better product and thicken the base with a little more stone and go. There is no engineering done. We haven't designed a project to use a grid or fabric from the beginning.
FL	See answer to Question 3. - The same materials used for base reinforcement are approved for subgrade (embankment) reinforcement
GA	We use fabric. See links below: http://www.dot.ga.gov/doingbusiness/Materials/qaqc/Documents/8216.pdf http://www.dot.ga.gov/doingbusiness/Materials/Documents/qaqcmanual/zip/8215qaqc.zip
ID	We often use biaxial geogrid and/or geotextile for pavement system subgrade stabilization.
IN	Biaxial geogrid Type IB
IA	No response
KS	We utilize both geosynthetics for stabilization as well as geogrids
LA	We use fabrics meeting Class D in our specifications.
ME	Non-woven geotextiles.
MD	Woven, Stabilization Geotextile, with 300 grab strength, very limited quantity of biaxial Geogrid is used by our office.
MI	Typically a Stabilization Geotextile is used for subgrade stabilization. This is typically a woven geotextile.
MN	Subgrade problem soils are stabilized with materials such as geocells as noted in the answer to question 3.
MO	Typically use biaxial geogrid. Starting to use Tensar Triax geogrid.
MT	Non-woven and woven geotextiles and geogrids are used for subgrade stabilization (i.e. establishing a working platform)
NE	We don't use often but we have used geotextiles and geogrids both
NV	Same as above [Question 3]: The geogrid shall be one of the following structure types: (A) A structure comprised of punched and drawn polypropylene (PP) or high-density polyethylene (HDPE) sheet integrally formed into a grid. (B) A structure comprised of high-density polyethylene (HDPE) or polypropylene (PP) extruded to form a grid.
NH	We don't typically use geosynthetic materials for this purpose although we have tried them on occasion.
NY	Either woven or non-woven materials are acceptable provided they meet the specification requirements here: https://www.dot.ny.gov/portal/pls/portal/mexis_app.pa_ei_eb_admin_app.show_pdf?id=11341

Table D-2. Types of Geosynthetic Materials Used for Subgrade Stabilization (Continued)

State	Response
NC	Geogrid and Geotextile
ND	We typically use Fabrics for subgrade stabilization, we have begun to use geogrids, but do not currently have anything in our specifications for geogrids.
OR	Subgrade Reinforcement Geogrid (see above). Types meeting these requirements: http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/qpl/docs/geogrid_subgrade_reinforcement.pdf
PA	Class 4 Geotextile and Geogrids Class 4, Type A Geotextile is used for separation. Subgrade stabilization would be essentially what was described above. Most successful geosynthetic stabilization has been with Geocell within the subbase. So not really subgrade stabilization – just very efficient load distribution through the subbase.
RI	We occasionally use a Biaxial or Triaxial geogrid to reinforce a pavement subbase and/or subgrade if problem areas are recognized. A separation filter fabric may also be used in conjunction with the geogrid if open graded backfills are used.
SC	Geogrids or a high strength woven geotextile are typically used for this purpose.
SD	Typically we use geotextiles.
TX	Same as Item 3 above. Additionally, heavy duty fabrics are used for specific instances that require a more stable foundation on which embankments and other pavement layers may be built. These are site specific designs.
UT	Geogrids, some fabrics within the sub-grade
VA	We have a category of subgrade stabilization fabric, see spec book link, the requirements are listed.

Table D-3. Types of Geogrids Used

State	Response
AL	Geogrids have been used when the designer requested their use in order to provide interlock with the aggregates used in stabilizing the subgrade. A separate geogrid specification has not been developed as of this time.
CA	See Section Geosynthetics in link: http://www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/Pavement_Foundations.html
CO	Geotextile and geogrid.
CT	Mostly for reinforced soil slope and mse (*sic*) wall systems.
DE	We don't have specifications for geogrid. We used geogrid reinforcement under pavement in one project recently where the undercut would have been prohibitively expensive. The contractor brought a geogrid manufacturer to us with a recommendation for a combination of undercut and his product. In the end, we used his product but rejected his recommendation for additional undercut. We used grid and fabric and an additional 12 inches of GABC. The underlying soil was a fat clay with a California Bearing Ratio (CBR) value less than 1 and completely saturated. This location is part of an ongoing project. The work was done late 2012/early 2013.
FL	Fabrics may be used with geogrids when constructing over soft soils.
GA	We have used geogrids for subgrade stabilization, embankment stabilization and reinforced slopes. Geogrids are typically easier to work w/ in inundated areas. Below are links to our Standard Specification and Special Provisions for geogrid: http://www.dot.ga.gov/doingbusiness/TheSource/specs/ss809.pdf http://www.dot.ga.gov/doingbusiness/Materials/Documents/qaqcmanual/zip/8214qaqc.zip http://www.dot.ga.gov/doingbusiness/Materials/Documents/qaqcmanual/zip/827qaqc.zip http://www.dot.ga.gov/doingbusiness/Materials/Documents/qaqcmanual/zip/826qaqc.zip Geogrids have also been used on two projects to reduce GAB thickness, when the total pavement thickness (JPC+ Interlayer+ GAB) was limited due to project constraints such as underground fiber optic cable trenches. The success or failure of this substitution has not been documented.
ID	We use geogrids for steep slope reinforcement, weak subgrade stabilization, MSE wall backfill reinforcement, pavement base reinforcement, pavement deep patch, and soft spot repair.
IN	Foundation soils are weak and needs improvement. Subgrade construction in urban area, and Wall reinforcements,
IA	No response
KS	In retaining wall systems, for reinforcements of embankment slopes and embankment foundations, and for soft subgrades along with aggregates.
LA	Geogrid usage is generally specified on a project basis (see attached specification) if deemed necessary by our Geotechnical Section.
ME	Road base, retaining walls, reinforced slopes.
MD	Geogrid along with the Geotextile to act as reinforcement and separation are used on the top of soft ground where the ground improvement is very expensive.
MI	As a higher strength subgrade stabilization or to bridge over isolated pockets of softer subgrade that can't be removed and replaced. Other uses of geogrid include MSE walls and steepened slopes.

Table D-3. Types of Geogrids Used (Continued)

State	Response
MN	Where interlocking with the aggregates is desired. Often used in wall reinforcement or the aggregate base course. We have a technical memo on them that includes a generic spec. Find it here: http://www.dot.state.mn.us/stateaid/techmemo/10-SA-03.pdf
MO	Geogrids are used for base reinforcement, soft subgrades. slope repairs, reinforced embankments/slopes, and MSE walls
MT	Geogrids are used for subgrade stabilization when it is estimated a geotextile alone is not sufficient. Uniaxial grids are used for MSE wall reinforcement.
NE	Most often geogrids are used for MSE/Modular block retaining walls, subgrade stabilization, embankment stabilization, to create a working platform for culvert construction, slope/landslide repairs.
NV	On soft subgrade; in combination with nonwoven fabric.
NH	We have used them on reinforced slopes on rare occasions, as well as a component of MSE wall systems.
NY	As soil backfill reinforcement, as part of certain mechanically-stabilized earth systems. We will also use them to reduce the depth of undercuts, or to increase the effectiveness of undercuts in extremely soft soils.
NC	Reinforced Steep Slope, Subgrade Stabilization, Embankment Stabilization, MSE Retaining Wall
ND	Occasionally in the base section and for construction of working platforms during construction in extremely soft situations.
OR	Two applications: 1) MSE retaining walls (Type 1 MSEW Geogrid); and 2) Pavement construction (Subgrade Reinforcement Geogrid). also Over utilities and where grade restraints will not allow design thickness of aggregate base.
PA	For subgrade stabilization, slope reinforcement, modular block retaining wall backfill reinforcement Uniaxial grids used for reinforcement applications (reinforced slopes and extensible reinforcement MSE walls). Biaxial grids for load distribution pads.
RI	We occasionally use a Biaxial or Triaxial geogrid to reinforce a pavement subbase and/or subgrade if problem areas are recognized. Also used more frequently in MSE Walls and, more recently, a few GRS abutments.
SC	Geogrids are sometimes used to reduce undercut quantities or in reinforced soil slope applications.
SD	Geogrids are used in applications where interlock with the granular backfill is a consideration and also where we need to obtain the strength of the geosynthetic at low strain or deformation, such as modular block walls.
TX	In Texas, geogrids are used with the greatest frequency for purposes of mitigating environmental edge cracking and reflective cracking from stabilized subbases. Geogrids are also used in specific designs where subbases might be compromised therefore lending support to upper pavement layers.

Table D-3. Types of Geogrids Used (Continued)

State	Response
UT	Mostly for sub-grade stabilization. Had a hard time with threats of law suits before Tensar patent ran out, which cause our pavement design engineers to say forget it we will just not use anything. Now we have several brands of Geogrid to choose from, but how do you come up with some kind of a standard to get what you need, some kind of a performance spec Anyway we want to form a western states team of Geogrid experts to look at a way to force the producers to have to go through some protocol where they had some kind of a Accelerated Pavement testing by some approve testing facilities here in the USA like the core of engineers or some universities. (SEE DRAFT, UDOT Usage Protocol for Using Geogrids in Flexible Pavement Structures) Then we can setup some kind of performance requirement from the data results line if you're above it you can be used in our pavement designs
VA	We rarely use geogrids because we do not account for them in the pavement design. They are typically used in special design applications for contractor construction purposes.

Table D-4. Use of Geotextile Fabrics with Geogrids for Separation

State	Response
AL	We routinely place a filter fabric between the fine grained soft soils and the geotextiles and aggregate above to prevent the migration of fines in to the stone matrix.
CA	Depends on natural filtration. See item 5 above
CO	Soft subgrade soil encountered.
CT	We have not used geogrids in combination with geotextile fabrics.
DE	We did use a combination of geogrid laying on top of a class 2 woven separation fabric. I had a recommendation from Dr. Al-qadi at University of Illinois that the grid should be embedded in the stone layer to provide more benefit. The benefit would be two fold: 1) It would give us the opportunity to calculate the benefit of the fabric after placing the first layer of GABC before committing to using the geogrid. 2) the tensile forces in the GABC are higher the closer you get to the wheel contact surface and dissipate through the depth of the layer. (the purpose of the grid is to provide tensile reinforcement – makes sense to me) Unfortunately, We placed the grid at the bottom of the GABC so I don't know which product is doing the work.
FL	Not Applicable (N/A)
GA	We do not specify this, however several manufacturers produce products w/ both a fabric and grid combined that is approved to be used on projects as long as it meets the requirements in the Special provisions on a project by project basis.
ID	Geotextile is often used below geogrid as a separation when fine grain soils, such as silt, exist at the subgrade.
IN	It is good to separate soils from the aggregates and geogrid with geotextile if pumping is concerned.
IA	No response
KS	If we have a particularly soft subgrade condition or foundation condition for an embankment.
LA	Our specification for geogrids does not mention a geotextile fabric. However, any such usage would be specified in the project.
ME	Road base, retaining walls, reinforced slopes.
MD	These are used when we want to have the reinforcement and separation benefits.
MI	These are used over soft soil where separation of different soil types is needed and additional strength or reinforcement is needed.
MN	We don't use geogrids for separation. If we want separation we use a fabric. If we need some strength or pullout capacity and separation for some reason then we may use both but often we just go with a fabric only and spec. the parameters needed. One example where we consider both types may be a large box culvert on soft soils that we cannot dig out and a rock platform 2' thick may be installed for bedding. A fabric may be placed first only for separation and a geogrid may be used in the crushed rock or even over the top of the box culvert.
MO	MODOT has used geotextile fabrics (separation) in conjunction with geogrids for soft sandy subgrade conditions and in slope repairs. The nonwoven fabric acted as a drainage system as well as reinforcement.
MT	If a geogrid is being used, we typically also use a separation geotextile
NE	Typically we use the combination of fabrics and geogrids with pavement subgrades in wet areas where the subgrade is weak and the soil type is dispersive in nature to prevent pumping of fines as well as stabilize.
NV	On saturated soft Subgrade.

Table D-4. Use of Geotextile Fabrics with Geogrids for Separation (Continued)

State	Response
NY	We typically use fabrics alone for separation in highway applications, and do not use them in conjunction with geogrids. We do, however, use geogrids and geotextiles together to construct our Geosynthetically Reinforced Soil Structure (GRSS) walls and slopes. In this application, the geogrid provides the strength and the fabric provides the separation.
NC	When geogrid is placed on fine grained soil
ND	We haven't used this approach.
OR	We use geotextiles for conventional applications (i.e., separation, reinforcement, filtration/drainage, etc…), but not typically as geogrid composite.
PA	I don't know if we would deliberately intend to use them together except for rare and unusual circumstances. We have strong geotextiles that we can pick from when we need strength. Kerry, your thoughts? Class 4, Type A exclusively used for separation. Geogrids not used for separation. Never used together for sole purpose of separation.
RI	With wrap-face MSE walls and as a separation layer when open graded backfills are used
SC	We typically do not use geogrids combined with other fabrics for separation. There have only been a couple of instances of this application on SCDOT work.
SD	In situations where soft soils and groundwater have the capability of transporting fines into an open graded backfill.
TX	This is not the usual case (I can't think of one instance where this was done). Generally, a fabric is needed before a grid would be more beneficial.
UT	No response
VA	Only if called for by special design/Special Provision.

Table D-5. Research or Performance Testing on Geogrids

State	Response
AL	Not to my knowledge.
CA	We have not done any lab testing on geogrids, but performed post construction performance evaluation of use of biaxial geogrid on HW 99 in California some 20 years ago.
CO	No.
CT	We have not lead any research in this area.
DE	no. The use of geogrids is very minimal and we can't expend the resources. I don't see us using grid reinforcement to design thinner pavement sections. I would however like to see more investigation into creating a standard like M288 to apply to grids. I think this would be a crucial first step to beginning to design pavements thinner using grids.
FL	http://materials.dot.state.fl.us/smo/pavement/research/reports/stateroad/15-93130.pdf [Bad Link] Correct link: August 2011 status report: Experimental Project Status Report, Geosynthetic Reinforcement Evaluation, Section/Subsection No. 93130-3508, State Road 15 http://www.dot.state.fl.us/statematerialsoffice/pavement/research/reports/stateroad/15-93130.pdf
GA	No research by GDOT.
ID	We have not conducted any research on the performances of geogrids.
IN	Please see the recently completed report: *Quality Assessment of Geogrids Used for Subgrade Treatment* See: http://docs.lib.purdue.edu/jtrp/1523/
IA	No response
KS	No
LA	We have not performed research or performance testing on geogrids to my knowledge. We have done some development of an updated geogrid specification, but we haven't completed it.
ME	Yes - with University of Maine: *Performance and Effectiveness of a Thin Pavement Section Using Geogrids and Drainage Geocomposite in a Cold Region* , (Christopher L. Helstrom 2005) Access to the full text document is restricted to students and faculty at the University of Maine. http://www.library.umaine.edu/theses/theses.asp?highlight=1&Cmd=abstrat&ID=CIE2005-003
MD	No
MI	No research or performance testing has been done by MDOT regarding geogrids.
MN	We test all our projects when they are built but seldom have reason to go back and test or exhume the geogrids. We have never had a problem with them other than for other reasons not related to the design or intended use. We do follow the national research on such matters and have contributed money to pooled fund research such as with Montana State University, Dr. Perkins but to do any ourselves would only repeat what others have done. We do have a geotextile spec. as well that is a bit like the AASHTO M288. I can get you that if desired.
MO	Not that I am aware of.

Table D-5. Research or Performance Testing on Geogrids (Continued)

State	Response
MT	http://www.pooledfund.org/Details/Study/479 http://www.mdt.mt.gov/research/projects/res_final.shtml (look under the "geotechnical" part of this page, we have completed a couple of different projects) *Evaluation of Geosynthetic Reinforced Flexible Pavement Systems Using Two Pavement Test Facilities* http://www.mdt.mt.gov/other/research/external/docs/research_proj/flex_pave/final_report.pdf *Feasibility of the Use of Existing Analytical Models and Experimental Data to Assess Current Design Methods for Pavement Geogrid-Reinforced Base Layers* http://www.mdt.mt.gov/other/research/external/docs/research_proj/analytical_model.pdf *Field Investigation of Geosynthetics Used for Subgrade Stabilization* http://www.mdt.mt.gov/other/research/external/docs/research_proj/subgrade/final_report.pdf *Geosynthetic Reinforcement of Flexible Pavements: Laboratory Based Pavement Test Sections* http://www.mdt.mt.gov/other/research/external/docs/research_proj/geo-reinforce.pdf Numerical Modeling of Geosynthetic Reinforced Flexible Pavements http://www.mdt.mt.gov/other/research/external/docs/grfp/nummodel_flexpavements.pdf
NE	We have not to my knowledge.
NV	We have not conducted research or performance testing on geogrids.
NH	No, we haven't.
NY	No
NC	No
ND	No
OR	http://www.oregon.gov/ODOT/td/tp_res/docs/reports/geosyreflectcrackcont_crpt.pdf Dated 1999 http://library.state.or.us/repository/2007/200707191253314/index.pdf *Geosynthetic Materials in Reflective Crack Prevention*, Current 2007
PA	Other than material prequalification and acceptance testing, no testing or research I am aware of for geogrids.
RI	RTE 165 in Richmond RI (summer 2013). Approximately 7 miles of reclaimed asphalt were used as a subbase. Several test strips were constructed using several different stabilizing techniques (emulsion, calcium, Portland cement and triaxial geogrid).
SC	We have not conducted research or performed testing on geogrids.
SD	No

Table D-5. Research or Performance Testing on Geogrids (Continued)

State	Response
TX	• Geosynthetic-Reinforced Unbound Base Courses: Quantification of the Reinforcement Benefits , Report 4829-01-1 (http://ftp.dot.state.tx.us/pub/txdot-info/rti/psr/4829.pdf) • Application Guide and Specifications for Geotextiles in Roadway Applications , Report 5812-1 (http://ftp.dot.state.tx.us/pub/txdot-info/rti/psr/5812.pdf) • Tests of HMA Overlays Using Geosynthetics to Reduce Reflection Cracking, Report 1777-3 (http://ftp.dot.state.tx.us/pub/txdot-info/rti/psr/1777.pdf)
UT	Some in progress with BYU (Brigham Young University)
VA	No, VDOT has not conducted any research.

APPENDIX E: SUMMARY OF STATE GEOSYNTHETIC SPECIFICATIONS

Gene Hansen, of the Chalmers Engineering Services, Inc. Research Team developed the following specifications ratings definitions. They are based on his professional experience with geosynthetics and his background in developing ADOT geosynthetic specifications.

Poor: The specification is out of date, insufficient to adequately define the material, has material requirements that cannot be met, no installation requirements, and as such would not be a good resource.

Average: The specification is out of date, but otherwise is somewhat reasonable, many times does not include much in the way of installation requirements, and is generally limited.

Good: The specification has all the materials requirements typically needed, is limited on installation requirements, may be somewhat out of date, but is generally a fairly comprehensive specification.

Very good: The specification is up to date, comprehensive, generally has good installation aspects, and could be a model specification depending on the type of specification chosen.

Table E-1. Geosynthetic Specification Summary—Alabama

State	Alabama				
Requirements for geotextiles are listed in Section 810 of the state specifications. It refers to AASHTO M288, but refers the reader to the different applications for the specific callouts. Most of these are listed in Section 600 Incidentals. Each installation specification calls out an AASHTO class, so this specification is very simple. If an APL is created based on the type of installation, it would simply put fabrics on the list that are identified.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	608 (2012) 810 (2012)	Refers to List II-3 of the APL, Article 608.02	M-288-06 Class 2	No	Good
Bank Protection/ Erosion Control	610 (d) (2012)	Refers to List II-3 of the APL, Article 610.02	M-288-06 Class 1	No	Good
Paving Fabric	607 (2012) 810 (2012)	Refers to List II-3 of the APL, Subarticle 607.02 (a)	M-288-06 Class 2	No	Poor, Incorrect
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	243 (2012)	Geogrids or Geotextiles, Types 1, 2, and 3	Does not follow AASHTO	No	Good
MSE Walls	N/A				
Reinforced Slopes	243 (2012)	Geogrids or Geotextiles, Types 1, 2, and 3	Does not follow AASHTO	No	Good
Retaining Walls	N/A				
Drainage	605 (2012) 810 (2012)	Refers to List II-3 of the APL. Subarticle 605.02 (a)	M-288-06 Class 2	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	665 (j) (2012 810 (2012	Refers to List II-3 of the APL, Subarticle 665-02 (j)	M 288-06 with modifications	No	Good
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-2. Geosynthetic Specification Summary—Alaska

State	Alaska				
Requirements for geosynthetic materials are listed in Section 729 of the state specifications. Section 729 is one page. The specification refers to AASHTO M288 for each type of use, but the classes are not identified. Some changes to M288 are identified for the different uses. The geogrid specification is for only one type. (This is similar to the ADOT specification.) Each installation specification refers to a subsection of 729, but in some cases, the special provision must identify the class of fabric.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	729-2.01 and 630 (2004)	None specified	AASHTO M288, min. permittivity of 0.05 sec^{-1}	No	Good
Bank Protection/ Erosion Control	729-2.02 and 631 (2004)	Class specified in bid schedule	AASHTO M288	No	Good
Paving Fabric	729-2.03 and 632 (2004)	None specified	AASHTO M288	No	Average
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	729-2.01 and 630 (2004)	None specified	AASHTO M288, min. permittivity of 0.08 sec^{-1}	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	729-2.02 and 631 (2004)	Class specified in bid schedule	AASHTO M288	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	729-2.04 and 633 (2004)	None specified	AASHTO M288	No	Average
Geogrid	729-2.05 and 634 (2004)	Must meet Table 729-1 Physical Requirements	Industry Specification	No	Average

(1) Rated by the Research Team

Table E-3. Geosynthetic Specification Summary—Arkansas

State	Arkansas				
Requirements for geotextiles are listed in Section 625 of the state specification, and all the specifications refer to AASHTO M288. Ten types of geotextile fabrics are identified. Some installation requirements are given within Section 625. Arkansas does not have a specification for geogrid.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	625.02, Types 8 and 9 (2003)	Woven or nonwoven synthetic filter fabric, Classes 2 and 3	AASHTO M288	No	Good
Bank Protection/ Erosion Control	625.02, Types 5 and 6 (2003)	Woven or nonwoven synthetic filter fabric, Classes 1 and 2	AASHTO M288	No	Good
Paving Fabric	625.02, Type 7 (2004)	Woven or nonwoven synthetic filter fabric	AASHTO M288	No	Average
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	625.02, Type 10 (2003)	Woven or nonwoven synthetic filter fabric, Class 1	AASHTO M288	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	625.02, Types 1 and 2(2003)	Woven or nonwoven synthetic filter fabric, Classes 2 and 3	AASHTO M288	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	625.02, Types 3 and 4 (2003))	Type 3 for supported silt fence, Type 4 for unsupported	AASHTO M288	No	Average

Table E-3. Geosynthetic Specification Summary—Arkansas (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Geogrid	N/A			No	

(1) Rated by the Research Team

Table E-4. Geosynthetic Specification Summary—California

State	California				
Requirements for geotextiles are listed in Section 88 of the state specification. California does not refer to AASHTO M288 at all. The state has its own specifications for a limited number of applications, such as paving, filter fabric, and slope protection fabric. There is no geogrid specification. There is no specification for a separation geotextile. California upgraded their specification in 2010 and added many other applications, including a geogrid specification, which has improved its functionality.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	88-1.02I (2010)	Permeable, nonwoven, needle-punched, Classes 8 and 10	Caltrans Spec	No	Good
Paving Fabric	88-1.02J (2010)	Does not specify	Caltrans Spec	No	Good
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	88-1.02O (2010)	Polyester or polypropylene, Classes A1, A2, B1, B2, and B3	Caltrans Spec, based somewhat on M288	No	Good
MSE Walls	N/A				
Reinforced Slopes	88-1.02D (2010)	Geotextile or geogrid with open area of 50-90%	Caltrans Spec with reference to GRI	Refers to GRI Standard Practice	
Retaining Walls	N/A				
Drainage	88-1.02B (2010)	Permeable and nonwoven, Classes A, B and C	Caltrans Spec	No	Good

Table E-4. Geosynthetic Specification Summary—California (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Wall Drains	88-1.02C (2010)	Polymeric core with filter fabric bonded to one or both sides	Caltrans Spec	No	Good
Edge Drains	N/A				
Silt Fence	88-1.02E (2010)	Does not specify, woven and nonwoven requirements	Caltrans Spec	No	Good
Geogrid	88-1.02P (7/9/13)	Punched and drawn polypropylene biaxial grid	Caltrans Spec	No	Good

(1) Rated by the Research Team

Table E-5. Geosynthetic Specification Summary—Colorado

State	Colorado				
Requirements for geotextiles are listed in 712.08 of the state specification. This is a very thorough specification. Colorado does not refer to AASHTO M288, but does refer to the Classes given in AASHTO M288. The state has its own specifications for geomembranes, erosion control, drainage and silt fence, paving geotextile, weed control, and separator. There is no specification for geogrid. There is a clearly written specification for geocomposite drains, Section 712.12. The 2011 specification was significantly modified and referred to the New York DOT approved products list for the different applications, largely eliminating many of the different specifications.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	712.08 (2011)	Specification refers to New York APL and NTPEP testing	AASHTO M288	Only within M288	Poor
Bank Protection/ Erosion Control	712.08 (2011)	Specification refers to New York APL and NTPEP testing	AASHTO M288	Only within M288	Poor
Paving Fabric	712.08 (2011)	Specification refers to New York APL and NTPEP testing	AASHTO M288	Only within M288	Poor
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	712.08 (2011)	Specification refers to New York APL and NTPEP testing	AASHTO M288	Only within M288	Poor
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	712.08 (2011)	Specification refers to New York APL and NTPEP testing	AASHTO M288	Only within M288	Poor
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	712.08 (2011)	Specification refers to New York APL and NTPEP testing	AASHTO M288	Only within M288	Poor
Geogrid	N/A				

(1) Rated by the Research Team

Table E-6. Geosynthetic Specification Summary—Connecticut

State	Connecticut				
Connecticut requirements for geotextiles are listed in their state specification Sections 2.19 (silt fence), 7.51 (underdrains), 7.55 (geotextile) and specified in M.8.01-26 (material specification), which refers to the Qualified Products List. The Qualified Products List gives the requirements for the different applications of geotextiles, but the geotextiles must conform to AASHTO M288. There are a few installation specifications, but most of the requirements for the geotextiles are not in the specification. There is no specification for geogrids.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	7.55, M.08.01-26 (2002)	High and Medium Survivability	Refers to QPL, uses 1992 AASHTO M288	No	Poor
Bank Protection/ Erosion Control	7.55, M.08.01-26 (2002)	Class A and Class B	Refers to QPL, uses 1992 AASHTO M288	No	Poor
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	7.51, M.08.01-26 (2002)	Class A and Class B	Refers to QPL, uses 1992 AASHTO M288	No	Poor
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	2.19.02, 7.55, M.08.01-26 (2002)	Wire Supported and Self Supported	Refers to QPL, uses 1992 AASHTO M288	No	Poor
Geogrid	N/A				

(1) Rated by the Research Team

Table E-7. Geosynthetic Specification Summary—Delaware

State	Delaware				
The requirements for geotextiles in the Delaware specification are in several state specification sections including 713, 715, and 827. Changes were made in a supplemental specification in 2008 to refer to AASHTO M288. The requirements for the primary uses of geotextiles are in sections 713 and 715, with miscellaneous and strange uses in section 827. Installation requirements are weak. This is a very limited specification. No geogrid or geocomposite drain specification was noted.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	713.03 (5/6/13)	AASHTO M288 Class 3 and Table 3	AASHTO M288	No	Good
Bank Protection/ Erosion Control	713-04 (5/6/13)	AASHTO M288, Class 2 Table 5 woven, Class 1, Table 5 non-woven	AASHTO M288	No	Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	713.02 (5/6/13)	AASHTO M288 Class 1 and Table 4	AASHTO M288	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	715.05 (5/6/13)	AASHTO M288 Class 2 or 3, Table 2	AASHTO M288	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	827.02, 251 (5/6/13)	AASHTO M288 Table 6	AASHTO M288	No	Good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-8. Geosynthetic Specification Summary—Florida

State	Florida				
The state specification for geotextile is Section 985, but it only refers to a Design Standard Drawing 0199, which lists the requirements for the different applications. The general classes are drainage, erosion, and stabilization with different requirements for different applications. There is no reference to M288 in the geotextile criteria. No reference to geogrid was found in their specification. Interim Design Index 501 calls out specific products for different types of soil reinforcement applications and includes fabrics and geogrids for that application. Florida's strongest area is design requirements for reinforced slopes.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation					
Bank Protection/ Erosion Control	985 (2014) Index No. 199	Woven or nonwoven fabrics, no woven slit film	Florida DOT	Yes, within table	Very good
Paving Fabric					
Pavement System Base Reinforcement					
Pavement System Subgrade Stabilization					
MSE Walls	985 (2014) Index No. 199	Woven or nonwoven fabrics	Florida DOT	No	Good
Reinforced Slopes	Index No. 501 (Not a spec)	Table of Approved Geosynthetic Products – Geotextiles, Geogrids	Florida DOT	Yes	Very good
Retaining Walls	985 (2014) Index No. 199	Woven or nonwoven fabrics	Florida DOT	No	Good
Drainage	985 (2014) Index No. 199	Woven or nonwoven fabrics, no woven slit film	Florida DOT	Yes, within table	Very good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	985 (2014) Index No. 199	Woven or nonwoven fabrics	Florida DOT	No	Good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-9. Geosynthetic Specification Summary—Georgia

State	Georgia				
Georgia has a specification for plastic filter fabric (Section 881-2.05). It has two parts, one for woven and one for nonwoven fabric. They also have a specification for pavement fabric. This is similar to ADOT's pavement fabric specification. There is no reference to AASHTO M288. Section 881-2.06 addresses two different types of pavement fabric with Section 446 for placement and 881-2.07 for silt fence fabric along with Section 171 for silt fence installation. Finally, there is Section 809 for geogrid materials to be used in geogrid-reinforced slopes and mechanically stabilized earth (MSE) wall systems. The state has comprehensive specifications for MSE wall systems installations using geogrids (Sections 626 and 627).					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	881-2.05 (2013)	Must be woven fabric	Georgia DOT NTPEP Evaluated	Use Guidelines	Poor
Paving Fabric	881-2.06 (2013)	Non-woven polypropylene or polyester – Types I and II	Georgia DOT	No	Good
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	809 -2, 626, 627 (2013)	Biaxial grid, copolymerized high density PE	Georgia DOT	No	Very Good
Reinforced Slopes	809-1 (2013)	Biaxial or uniaxial, high density PE or polypropylene stretched	Georgia DOT	No	Good
Retaining Walls	N/A				
Drainage	881-2.05 (2013)	Must be non-woven or woven fabric that meet flow rate	Georgia DOT NTPEP Evaluated	Use Guidelines	Poor
Wall Drains	881-2.05 (2013)	Must be non-woven or woven fabric that meet flow rate	Georgia DOT NTPEP Evaluated	Use Guidelines	Poor

Table E-9. Geosynthetic Specification Summary—Georgia (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Edge Drains	881-2.05 (2013)	Must be non-woven or woven fabric that meet flow rate	Georgia DOT NTPEP Evaluated	Use Guidelines	Poor
Silt Fence	881-2.07 and 171 (2013_	Woven or non-woven, UV and heat resistant, Types A, B, and C	Georgia DOT NTPEP Evaluated	Installation Guidelines	Very Good
Geogrid	See above				

(1) Rated by the Research Team

Table E-10. Geosynthetic Specification Summary—Hawaii

State	Hawaii				
The state has a comprehensive specification. The requirement for geotextiles is in Section 716, and it covers all types. However, the specification needs to be updated. It does not refer to AASHTO M288, but has some of the AASHTO M288 numbers for permanent erosion. Section 646 for retaining wall and slope drainage limits geocomposite drains to 8 feet in height. Section 313 covers the installation of the geotextile permeable separator. The specification does not use permittivity as a requirement for drainage applications.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	716.02 (2005)	Long-chain polymeric fibers or yarns, 95% polyolefins or polyesters	Hawaii DOT	No	Good
Bank Protection/ Erosion Control	716.07 (2005)	Long-chain polymeric fibers or yarns, 95% polyolefins or polyesters	Looks like Caltrans	Yes	Very Good
Paving Fabric	716.04 (2005)	Long-chain polymeric fibers or yarns, 95% polyolefins or polyesters	Hawaii DOT	No	Average
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	716.06 (2005)	Long-chain polymeric fibers or yarns, 95% polyolefins or polyesters	Hawaii DOT	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	716.02 (2005)	Long-chain polymeric fibers or yarns, 95% polyolefins or polyesters	Hawaii DOT	No	Poor No Permittivity
Wall Drains	716.05 (2005)	One-side permeable, fabric meets basic requirements	Hawaii DOT	No	Poor No Permittivity
Edge Drains	N/A				
Silt Fence	716.08 (2005)	Long-chain polymeric fibers or yarns, 95% polyolefins or polyesters	Hawaii DOT	No	Good
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-11. Geosynthetic Specification Summary—Idaho

State	Idaho				
The Idaho 2012 specification does not refer to or follow AASHTO M288. The requirements for geotextiles are listed in Section 718, and include different types of geotextiles for different applications. The specification has the same permittivity requirements as the ADOT specification for drainage and bank protection. However, the Idaho specification has been updated with the new test methods. There is a complete installation specification for most of the geotextile applications in Section 640. There is no geogrid specification.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	718.07, 640.03 (2012)	Long-chain polymeric fibers or yarns, 85% polyolefins, polyesters, or polyamides, Types I, II, and III, woven or nonwoven	Idaho DOT	No	Very good
Bank Protection/ Erosion Control	718.07, 640.03 (2012	Long-chain polymeric fibers or yarns, 85% polyolefins, polyesters, or polyamides, Types I and II, nonwoven or monofilament woven	Idaho DOT	No	Very good
Paving Fabric	718.07, 640.03 (2012	Long-chain polymeric fibers or yarns, 85% polyolefins, polyesters, or polyamides, only nonwoven	Idaho DOT	No	Good
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	718.07, 640.03 (2012	Long-chain polymeric fibers or yarns, 85% polyolefins, polyesters, or polyamides, Types I and II, nonwoven or monofilament woven	Idaho DOT	No	Very good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	718.07, 640.03 (2012	Long-chain polymeric fibers or yarns, 85% polyolefins, polyesters, or polyamides	Idaho DOT	No	Good

Table E-11. Geosynthetic Specification Summary—Idaho (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-12. Geosynthetic Specification Summary—Illinois

State	Illinois				
Illinois produced a new 2012 specification. The requirements for geotextiles are listed in Section 1080 for fabric materials. Physical requirements are listed for fabric envelope for pipe underdrains, which does not refer to AASHTO M288. For silt fence, they refer to AASHTO M288. For stabilization, the physical requirements are listed. For filter fabric for bank protection, the strength of the fabric is based on the size gradation of the rip rap, and requirements to resist piping and permeability requirements are listed depending on an evaluation of the on-site soils, which would have to be listed in a special provision. They also have a specification for fabric utilized for French drains, which lists no permittivity requirements. There was no specification for geogrid. There was specification 1040 which included the wall drain material. Specification 282 is for filter fabric (bank protection fabric installation). Section 601 covers the placement of fabric for French drains.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/a				
Bank Protection/ Erosion Control	1080.03 (2012)	Nonwoven, long-chain polymer, 85% of polyolefins, or polyesters, specified for two different gradations of riprap	Illinois DOT	Yes	Average
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	1080.02 (2012)	Woven or nonwoven fabric, polypropylene, polyester, polyethylene. Nonwoven may be needle-punches, heat and/or resin bonded	Illinois DOT	No	Average
MSE Walls	N/A				
Reinforced Slopes	N/A				

Table E-12. Geosynthetic Specification Summary—Illinois (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Retaining Walls	N/A				
Drainage	1080.01 and 1018.05 (2012)	Knitted fabric, woven or nonwoven fabric, polypropylene, polyester, polyethylene	Illinois DOT	No	Poor
Wall Drains	1040.07 (2012)	Flexible geocomposite, polyethylene structure or core bonded to geotextile	Illinois DOT	No	Average
Edge Drains	N/A				
Silt Fence	1080.02 (2012)	Woven fabric	AASHTO M288	No	Good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-13. Geosynthetic Specification Summary—Indiana

State	Indiana				
Indiana has a new 2014 specification which includes geogrids (Section 918). The geotextile specifications are outdated. They have specifications for geotextile for use under riprap, for use with underdrains, and for silt fence. The updated geogrid specification includes four different geogrid specifications, Type IA, Type IB, Type II, and Type III. The difference between Type IA and IB is that Type IA has no junction strength requirement, so it must be for a fabric geogrid. For geotextiles, there are specifications for installation of erosion control filter fabrics and silt fence (Section 205), and for geogrids (Section 214).					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	918.02 (2014)	Nonwoven, plastic yarn or fibers, 85% polyolefins, polyesters or polyamides	Indiana DOT	No	Good Needs Updating
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				

Table E-13. Geosynthetic Specification Summary—Indiana (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Pavement System Subgrade Stabilization	214.04, 918.05 (2014)	Type IA for embankment foundations Type IB for subgrade treatment	Indiana DOT	No	Average
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	918.03 (2014)	Non-woven needle punched or heat bonded, 85% polyolefins, polyesters or polyamided	Indiana DOT	No	Poor Not strong enough
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	918.04 (2014)	Woven or nonwoven, 85% polyolefins, polyesters or polyamides	AASHTO M288 and Task Force 25, Indiana DOT	No	Good
Geogrid	918.05 (2014)	Biaxial or Multi Axial, polypropylene? Types IA or IB, Type II and Type III – HDPE, polypropylene, PP or polyester, PET?	Indiana DOT	No	Confusing

(1) Rated by the Research Team

Table E-14. Geosynthetic Specification Summary—Iowa

State	Iowa				
Requirements for geotextiles are listed in the 2012 Iowa Specifications, Section 4196, Engineering Fabrics. There are specifications for silt fence, subsurface drainage (permittivity range), under erosion stone (bank protection), under asphalt mixtures (paving fabric), subgrade stabilization (geogrid), fabric under concrete/stone revetment and abutment backfill. They do not follow AASHTO M288. Geogrid is also utilized in modular block and segmental retaining walls. They have excellent specifications for these two types of wall systems. ADOT does not currently use these systems. Also, Iowa has an excellent specification for MSE walls.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	4196.01 B. 3. (2012)	None Listed, permittivity range excludes nonwoven fabrics, elongation requirement excludes most woven fabrics	Iowa DOT	No	Very poor
Paving Fabric	4196.01 B. 4. (2012)	None Listed	Iowa DOT	No	Poor
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	4196.01 B. 5. (2012)	Polymer grid, no junction strength requirement	Iowa DOT	No	Poor
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls Modular Block Segmental	2430 and 2431 (2012)	Geogrid as specified by the design engineer	Iowa DOT	No	N/A
Drainage	4196.01 B. 2. (2012)	None Listed, permittivity range excludes nonwoven fabrics, elongation requirement excludes most woven fabrics	Iowa DOT	No	Very poor
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	4196.01 B. 1. (2012)	Woven material	Iowa DOT	No	Good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-15. Geosynthetic Specification Summary—Kansas

State	Kansas				
The Kansas 2007 specification Section 1710 has been updated by Special Provision 07-17004, which gives requirements for paving fabric, subsurface drainage, separation, base course reinforcement (geogrid), and subgrade stabilization (geogrid). The specifications for geotextiles refer to AASHTO M288 requirements. The junction strength requirement only applies to the geogrid, but geotextiles and geogrids are utilized interchangeably or together to meet the requirements. The requirements for wall drains are listed in Section 1706. They also have a geomembrane special provision and separation fabric special provision.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	1710.2e. (2007)	Woven or nonwoven, no slit tape or film woven, Class 2	AASHTO M288	No	Good
Bank Protection/ Erosion Control	N/A				
Paving Fabric	1710.2c. (2007)	Nonwoven geotextile	AASHTO M288	No	Good
Pavement System Base Reinforcement	1710.2f. (2007)	Single-layer geogrid or woven geotextile	Kansas DOT	No	Good
Pavement System Subgrade Stabilization	1710.2g. (2007)	Woven geotextile, geogrid, or geogrid/geotextile combination	Kansas DOT	Yes	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	1710.2d. (2007)	Woven or nonwoven, no slit tape or film woven, Class 2	AASHTO M288	No	Good
Wall Drains	1706.2 (2007)	High impact polymer core with an attached Class 2 geotextile	AASHTO 288 for the geotextile, Kansas DOT for the core	No	Good
Edge Drains	N/A				
Silt Fence	N/A				
Geogrid	See above				

(1) Rated by the Research Team

Table E-16. Geosynthetic Specification Summary—Kentucky

State	Kentucky				
The Kentucky 2012 specification for geotextile fabrics is Section 843. This specification contains the material specifications for five types of fabrics, ranging from geotextiles for slope protection and channel lining (Type I), geotextiles for underdrains (Type II), geotextiles for subgrade or slope stabilization (Type III), geotextiles for embankment drainage blankets and edge drains (Type IV), and high strength geotextile fabric (Type V). They also have a specification for geogrid reinforcement for subgrade and aggregate base course, Section 304, which gives material and placement requirements. Only the one type of geogrid is allowed, but the opening size of the geogrid is based on the gradation of the Aggregate Base Course (ABC), and the geogrid must be used in conjunction with a geotextile to provide separation. Section 214 gives the placement requirements for the different geotextile applications. Section 845 gives the requirement for fabric-wrapped backfill drains, which are essentially placed at the level of the weephole drains, but no wall drains. Kentucky also has some special provisions for alternative geogrid for base and asphalt reinforcement which bear looking at. None of the specifications refer to AASHTO M288.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	843 Type I, 214.03.03 (2012)	Woven or nonwoven, specifies minimum 20 gal/min/ft flow rate	Kentucky DOT Old Test Methods	No	Average
Paving Fabric					
Pavement System Base Reinforcement	304, Special Note (2012)	Geogrid composed of polypropylene or high density polyethylene, Types 1& 2	Kentucky DOT	No	Good
Pavement System Subgrade Stabilization	843 Type III, 214.03.05 (2012)	Woven or nonwoven, specifies minimum 7 gal/min/ft flow rate	Kentucky DOT Old Test Methods	No	Average
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	843 Type II, 214.03.04 (2012)	Woven or nonwoven, specifies minimum 50 gal/min/ft flow rate	Kentucky DOT Old Test Methods	No	Average
Wall Drains	N/A				
Edge Drains	843 Type IV, 214.03.06(2012)	Woven or nonwoven, specifies minimum 40 gal/min/ft flow rate	Kentucky DOT Old Test Methods	No	Average
Silt Fence	N/A				

Table E-16. Geosynthetic Specification Summary—Kentucky (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Geogrid	304, Special Note (2012)	Geogrid composed of polypropylene or high density polyethylene, Types 1& 2	Kentucky DOT	No	Good

[(1)] Rated by the Research Team

Table E-17. Geosynthetic Specification Summary—Louisiana

State	Louisiana				
The materials requirements are given in state specification Section 1019, Geotextile Fabrics and Geocomposite Systems. The products are split up into Classes A, B, C, D, F, G, and S with many applications which call out the different classes. The requirements for all the classes are listed in one table. However, this table needs to be updated. It does not conform to AASHTO M288, but the table is convenient and concise. There are also specifications for geocomposites, wall drains, and pavement fabric, which also reference the classes previously identified. A class D separator geotextile is required under ABC over all untreated or lime-treated subgrade soil. Geotextile placement is covered in 203.11 of the earthwork specifications. Section 204.03 includes material requirements for silt fence, class F and G. Construction entrances also require geotextile fabric below the stone. Geotextiles are used extensively in many applications.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	1019.01 (b) (2) (2006)	85% polyolefins, polyesters or polyamides, Class D	Louisiana DOT Old Test Methods	No	Average
Paving Fabric	1019.01 (b) (3), 1019.03 (2006)	85% polyolefins, polyesters or polyamides, Classes B or C (modified)	Louisiana DOT Old Test Methods	No	Average
Pavement System Base Reinforcement					
Pavement System Subgrade Stabilization	1019.01 (b) (2), 203.11 (2006)	85% polyolefins, polyesters or polyamides, Classes C, D, or S	Louisiana DOT Old Test Methods	No	Average
MSE Walls					
Reinforced Slopes					

Table E-17. Geosynthetic Specification Summary—Louisiana (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Retaining Walls					
Drainage	1019.01 (b) (1) (2006)	85% polyolefins, polyesters or polyamides, Classes A, B, C, or D	Louisiana DOT Old Test Methods	No	Average
Wall Drains	1019.02 (a) and (b)	Nonwoven geotextile fabric,, Class B, C, or D, and core	Louisiana DOT Old Test Methods	No	Average
Edge Drains					
Silt Fence	1019.01 (b) (4), 204.03 (e) (2006)	85% polyolefins, polyesters or polyamides, Wire supported Class F, Self Supported Class G	Louisiana DOT Old Test Methods	No	Average
Geogrid	Item S Geogrid(04/01)	Biaxially oriented polymer grid structure, polypropylene or polyethylene	Louisiana DOT	No	Good

(1) Rated by the Research Team

Table E-18. Geosynthetic Specification Summary—Maine

State	Maine				
The requirements for installation of geotextiles are listed in Section 620 of the state specifications. The material requirements are listed in Section 722 for stabilization/reinforcement, drainage, erosion control, and separation. This specification follows AASHTO M288 except that it is not updated. Overall the installation and material specifications are thorough for the applications specified, so they are useful for purposes of this study. They are somewhat similar to ADOT specifications, but simpler. Geogrids and geocomposite are not in the standard specification. There is a special provision for geogrid in addition to Section 620. The material specification is within it.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	722.04, 620.03	Woven and nonwoven, no slit film	AASHTO M288, Class 2, Table 2, Old Puncture	No	Good
Bank Protection/ Erosion Control	722.03, 620.03 c.	Woven or nonwoven, no slit film, woven monofilament – Class 2	AASHTO M288, Class 1 Old Puncture	No	Very Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	722.01, 620.03 a.	Woven or nonwoven	AASHTO M288, Class 1 Old Puncture	No	Very Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	722.02, 620.02 b.	Woven and nonwoven, no slit film	AASHTO M288, Class 2, Table 2, Old Puncture	No	Very Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	N/A				
Geogrid	N/A				

(1) Rated by the Research Team

Table E-19. Geosynthetic Specification Summary—Maryland

State	Maryland				
Maryland has a comprehensive table for geotextiles in Subsection 921.09 Geotextiles, SD subsurface drainage, PE permanent erosion, SE separation, SE separation, ST stabilization, F silt fence, It has been updated by special provision to conform to AASHTO M288 strength requirements, but not for the permittivity and apparent opening size (AOS) requirements, which are specific to Maryland. Installation Specifications are included in Sections 211 (subgrade stabilization), 306 (subsurface drainage), and 308 (silt fence). The specifications include geogrids in MSE walls, but there is no reference to geogrids in the specification.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	921.09.01 S (2008)	Nonwoven and Woven	Maryland DOT Puncture Strengths Wrong	No	Good
Bank Protection/ Erosion Control	921.09.01 PE (2008)	Nonwoven and Woven Monofilament, Types I, II and III	Maryland DOT Puncture Strengths Wrong	No	Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	921.09.01 ST, 211 (2008)	Woven	Maryland DOT Puncture Strengths Wrong	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	921.09.01 SD, 306 (2008)	Nonwoven and Woven Monofilament, Types I and II	Maryland DOT Puncture Strengths Wrong	No	Good
Wall Drains					
Edge Drains	922.02, 307 (2008)	Flexible rectangular conduit, drainage core, geotextile encased	Maryland DOT	No	
Silt Fence	921.09.01 F, 308.03.29 (2008)	Woven	Maryland DOT Puncture Strengths Wrong	No	Good
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-20. Geosynthetic Specification Summary—Massachusetts

State	Massachusetts				
Massachusetts simply refers to AASHTO M288 for the material requirements for geotextiles in their supplemental specifications. This can make it very difficult for field engineers to determine what geotextile to use on a project unless there is a special provision required for each project. There is no geogrid specification. Their qualified construction products list does not match up to AASHTO M288, which could result in difficulties.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	M9.50.0, QCML (2012)	Refers to AASHTO M288 for intended application, Class 1	AASHTO M288	No	Poor
Bank Protection/ Erosion Control	M9.50.0, QCML (2012)	Refers to AASHTO M288 for intended application, Class 1 or 2	AASHTO M288	No	Poor
Paving Fabric	M9.50.0, QCML (2012)	Refers to AASHTO M288 for intended application	AASHTO M288	No	Poor
Pavement System Base Reinforcement					
Pavement System Subgrade Stabilization	M9.50.0, QCML (2012)	Refers to AASHTO M288 for intended application, Class 1	AASHTO M288	No	Poor
MSE Walls					
Reinforced Slopes					
Retaining Walls					
Drainage	M9.50.0, QCML (2012)	Refers to AASHTO M288 for intended application, Class 1 or 2	AASHTO M288	No	Poor
Wall Drains					
Edge Drains					
Silt Fence	M9.50.0, QCML (2012)	Refers to AASHTO M288 for intended application, Table 7	AASHTO M288	No	Poor
Geogrid					

[(1)] Rated by the Research Team

Table E-21. Geosynthetic Specification Summary—Michigan

State	Michigan				
Michigan has a geosynthetic specification, Section 910, which gives materials requirements for at least six applications as well as for geocomposite drains. This is similar to ADOT's specification with regard to applications. It does not use survivability, but uses one table to cover everything. This makes it easy to use. The specification for materials requirements requires updating. Geogrids are not in the specification.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	910.03C, Table 910-1 (2012)	Woven or Nonwoven requirements	Michigan DOT Needs Updating	No	Good
Bank Protection/ Erosion Control	910.03A B, Table 910-1 (2012)	Must be nonwoven		No	Average
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	910.-3C, Table 910-1 (2012)	Woven or Nonwoven	Michigan DOT Needs Updating	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	910.03A, Table 910-1 (2012)	Nonwoven	Michigan DOT Needs Updating	No	Good
Wall Drains	910.05B and C, Table 910-1 (2012)B	Impermeable polymer core (B) with geotextile on one side or net (C) with geotextile on two sides	Michigan DOT Needs updating	No	Good
Edge Drains	910.05 A, Table 910-1	Geotextile stretches around a core and bonded to itself, at least 1" thick	Michigan DOT Needs updating	No	Good
Silt Fence	910.04, Table 910-1 (2012)	Elongation requirement limits to nonwoven	Michigan DOT	No	Average
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-22. Geosynthetic Specification Summary—Minnesota

State	Minnesota				
Minnesota plans to publish a new 2014 specification which refers to a new supplemental 2014 specification for geotextiles by their Materials Laboratory. The specification Section 3733 calls out the requirements for six types of geotextiles, including type 1 fabric around subdrainage pipes or drainage pipe connections, types 3 and 4 for moderate or severe bank protection, type 5 for separation, type 6 for earth reinforcement, and type 7 for steeper slope bank protection. Requirements for geotextiles for silt fences are given in Section 3886.2 of the standard specification, which appears to be very thorough. Types of geotextile are called out for specific applications in the standard specifications. Minnesota, like other states that receive high levels of precipitation, uses geotextiles to keep fines out of drain pipes. Minnesota uses granular equivalents for design of roadway pavement sections.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	3733, Type 5 (2014)	Woven, nonwoven, or knit fabric of polymeric filament or yarns, stable	Minnesota DOT	No	Good
Bank Protection/ Erosion Control	3733, Types 3, 4 and 7 (2014)	Woven, nonwoven, or knit fabric of polymeric filament or yarns, stable, needle-punch nonwoven for Type 7	Minnesota DOT	Yes, based on Class of riprap	Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	3733, Type 5 (2014)	Woven, nonwoven, or knit fabric of polymeric filament or yarns, stable	Minnesota DOT	No	Good
MSE Walls	N/A				
Reinforced Slopes	3733, Type 6 (2014)	Woven, nonwoven, or knit fabric of polymeric filament or yarns, stable	Minnesota DOT Specified in contract	No	Good
Retaining Walls	N/A				
Drainage	3733, Type 1 (2014)	Woven, nonwoven, or knit fabric of polymeric filament or yarns, stable	Minnesota DOT	No	Good
Wall Drains	N/A				
Edge Drains	N/A				

Table E-22. Geosynthetic Specification Summary—Minnesota (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Silt Fence	3886.2 (2012)	Woven or nonwoven depending on type, Types MS, HI, PA, SD and TB	Minnesota DOT	Yes	Very good
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-23. Geosynthetic Specification Summary—Mississippi

State	Mississippi				
The requirements for geotextiles are listed in Section 714.13 of the state specifications, and include seven types of geotextiles. These are sediment control (silt fence) Types I and II, drainage Type III, paving Type IV, separation and drainage Type V, separation, stabilization, and reinforcement Types VI and VII. The specification requires updating to new requirements. It is formatted to a single table. This is very similar to Maryland. It does not conform to AASHTO M288. They also have a specification for a moisture barrier (Section 714-14) and several classes of geogrid (Section 714-15). The geogrid specification has no junction strength requirement. It also includes requirements for silt fence. Section 209 is for geotextile stabilization. Geogrids are called out in Section 809, which is a specification for MSE wall systems, similar to Iowa. Geogrid applications for subgrade and slope reinforcement are included in Section 204.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	714.13.6, Types V, VI or VII (2004)	Woven or nonwoven, 95% by weight of polyolefins, polyesters or polyamides	Mississippi DOT Needs updating	No	Good
Bank Protection/ Erosion Control	714.13.5, Type V (2004)	Woven or nonwoven, 95% by weight of polyolefins, polyesters or polyamides	Mississippi DOT Needs updating	No	Good
Paving Fabric	714.13.4, Type IV (2004)	Nonwoven polyester or polypropylene	Mississippi DOT	No	Good
Pavement System Base Reinforcement					
Pavement System Subgrade Stabilization	714.13.6, Types VI or VII (2004)	Woven or nonwoven, 95% by weight of polyolefins, polyesters or polyamides	Mississippi DOT Needs updating	No	Good
MSE Walls					

Table E-23. Geosynthetic Specification Summary—Mississippi (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Reinforced Slopes					
Retaining Walls					
Drainage	714.13.3, Type III (2004)	Woven or nonwoven, 95% by weight of polyolefins, polyesters or polyamides	Mississippi DOT Needs updating	No	Good
Wall Drains					
Edge Drains	714.13.3.1, Type V (2004)				
Silt Fence	714.13.2, Types I or II (2004)	Woven or nonwoven, 95% by weight of polyolefins, polyesters or polyamides	Mississippi DOT	No	Poor Too low strength
Geogrid	714.15, Types I to VI (2004)	Geosynthetic formed by a regular network of integrally connected elements with apertures greater than 0.25 inch	Mississippi DOT	No	Very good Needs guidance

(1) Rated by the Research Team

Table E-24. Geosynthetic Specification Summary—Missouri

State	Missouri				
Missouri utilizes AASHTO M288 for geotextiles except as modified in the specifications, Section 1011. The modifications are primarily the permittivity and call out a specific class. The permittivity modification excludes woven geotextiles for most applications. They use a very strong non-woven fabric for unbounded concrete overlays. They have a specification (Section 605.20) for geocomposite edge drains. Section 624 is for geotextile construction. Section 1012 is for geocomposite edge drain. Section 806.7 is for silt fence.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	1011.3.4, 624 (12/13)	Nonwoven based on permittivity requirement, Class 1	AASHTO M288 modified	No	Very good
Bank Protection/ Erosion Control	1011.3.3, 624 (12/13)	Nonwoven based on permittivity requirement, Class 1 or 2	AASHTO M288 modified	No	Very good
Paving Fabric	N/A	Do have an field approved product list for paving fabric	No specification	No	N/A
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	1011.3.1, 624 (12/13)	Nonwoven based on permittivity requirement, Class 2	AASHTO M288 modified	No	Very good
Wall Drains	1012.3.3 (12/13)	Plastic core with a geotextile attached to one or both sides	AASHTO M288 and Missouri DOT	No	Very good
Edge Drains	1012.3.2, 605.20 (12/13)	Plastic core completely surrounded by geotextile	AASHTO M288 and Missouri DOT	No	Very good
Silt Fence	1011.3.2 (12/13)	Supported or non-supported sediment control fencing	AASHTO M288	No	Very good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-25. Geosynthetic Specification Summary—Montana

State	Montana				
Montana has specifications for installation (Section 622) and materials (Section 716). Montana does not use low survivability fabrics. The specification somewhat follows AASHTO M288, and the puncture strength test method and requirements have been modified by a supplemental specification to conform to the new requirements in AASHTO M288. The permittivity and AOS is somewhat modified from AASHTO M288, but is dependent on the class called out. Slit-film wovens cannot be used for subdrainage or permanent erosion control applications. Specifications for stabilized and unstabilized silt fence are called out. The installation specification is excellent. There are no specifications for geogrids or geocomposite drain materials. There is a special provision for geogrids, but it requires contacting the geotech department for the physical requirements.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	716.02, 622 (2006)	Woven or nonwoven, moderate or high survivability	AASHTO M288 updated supplemental 1/16/14	No	Very good
Bank Protection/ Erosion Control	716.05, 622 (2006)	Woven or nonwoven, no woven slit film, Classes A, B, or C, moderate or high survivability as specified	AASHTO M288 updated supplemental 1/16/14	Yes, based on soil	Very good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	716.03, 622 (2006)	Woven or nonwoven, no woven slit film, high survivability	AASHTO M288 updated supplemental 1/16/14	No	Very good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	716.04, 622 (2006)	Woven or nonwoven, no woven slit film, Classes A, B, or C, moderate or high survivability as specified	AASHTO M288 updated supplemental 1/16/14	Yes, based on soil	Very good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	716.06, 622 (2006)	Stabilized or unstabilized depending on method of support	Montana DOT	No	Very good

Table E-25. Geosynthetic Specification Summary—Montana (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-26. Geosynthetic Specification Summary—Nebraska

State	Nebraska				
Nebraska puts geotextiles on the approved product lists and tests them for strength requirements of AASHTO M288. There does not appear to be a specification for geotextiles in the standard specification. There was a specification for geogrid MSE walls similar to Iowa and application specifications for bank protection fabric and silt fence.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A	Uses APL for product approval, Classes I, II, and III, woven and nonwoven	Tested in accordance with AASHTO M288	No specification	N/A
Bank Protection/ Erosion Control	N/A	Uses APL for product approval	Tested in accordance with AASHTO M288	No specification	N/A
Paving Fabric	N/A				N/A
Pavement System Base Reinforcement	N/A				N/A
Pavement System Subgrade Stabilization	N/A	Uses APL for product approval, Classes I, II, and III, woven and nonwoven	Tested in accordance with AASHTO M288	No specification	N/A
MSE Walls	N/A				N/A
Reinforced Slopes	N/A				N/A
Retaining Walls	N/A				N/A
Drainage	N/A	Uses APL for product approval	Tested in accordance with AASHTO M288	No specification	N/A
Wall Drains	N/A				N/A
Edge Drains	N/A				N/A
Silt Fence	N/A				N/A
Geogrid	N/A	Uses APL for product approval, uniaxial or biaxial	Specified on an individual project design basis	No specification	N/A

(1) Rated by the Research Team

Table E-27. Geosynthetic Specification Summary—Nevada

State	Nevada				
Nevada does not have specifications for geosynthetics.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	No specification or APL				N/A
Bank Protection/ Erosion Control	No specification or APL				N/A
Paving Fabric	No specification or APL				N/A
Pavement System Base Reinforcement	No specification or APL				N/A
Pavement System Subgrade Stabilization	No specification or APL				N/A
MSE Walls	No specification or APL				N/A
Reinforced Slopes	No specification or APL				N/A
Retaining Walls	No specification or APL				N/A
Drainage	No specification or APL				N/A
Wall Drains	No specification or APL				N/A
Edge Drains	No specification or APL				N/A
Silt Fence	No specification or APL				N/A
Geogrid	No specification or APL				N/A

(1) Rated by the Research Team

Table E-28. Geosynthetic Specification Summary—New Hampshire

State	New Hampshire				
The requirements for geotextiles are listed in Section 593 of the standard specifications (2010). The geotextiles are separated out by application (four types), strength class (four classes) and structure (four types).The specification refers to AASHTO M288 for the first three strength classes, and calls out permittivity requirements for the different applications. Section 593 of the specification also includes the installation specifications for each application. Geogrids and geocomposites are not included in the specification.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	593-2.2.2 (2010)	Utilizes NTPEP for the approved product list for Classes 1, 2, and 3	AASHTO M288 Modified		Very good
Bank Protection/ Erosion Control	593-2.2.4 (2010)	Utilizes NTPEP for the approved product list for Classes 1, 2, and 3	AASHTO M288 Modified		Very good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	593-2.2.3 (2010)	Utilizes NTPEP for the approved product list for Classes 1, 2, and 3	AASHTO M288 Modified		Very good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	593-2.2.1 (2010)	Utilizes NTPEP for the approved product list for Classes 1, 2, and 3	AASHTO M288 Modified		Very good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	N/A				
Geogrid	N/A				

(1) Rated by the Research Team

Table E-29. Geosynthetic Specification Summary—New Jersey

State	New Jersey				
New Jersey has a table in Section 919 of the state specifications that refers to AASHTO M288, and calls out the class for subsurface drainage, stabilization, temporary silt fence, erosion control, and paving fabric. It refers to AASHTO M288 as a test method, but it is actually a specification. Geogrids and geocomposites are not referred to in the specification.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	919.01 (2007)	According to AASHTO M288, Class 1 or 2	AASHTO M288	No	Good
Paving Fabric	919.01 (2007)	According to AASHTO M288	AASHTO M288	No	Good
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	919.01 (2007)	According to AASHTO M288, Class 2	AASHTO M288	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	919.01 (2007)	According to AASHTO M288	AASHTO M288	No	Good
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-30. Geosynthetic Specification Summary—New Mexico

State	New Mexico				
The specifications for geotextiles for New Mexico are presented in Section 604. Initially, the material requirements are called out, referring to AASHTO M288 for the strength requirements by class. Slit-film fabrics are not allowed for subsurface drainage and erosion protection applications. Stabilization fabrics are to be used in wet unstable soil condition when the resistance value (R-value) ranges from 10 to 20. The construction requirements follow after the material requirements for each application. However, no material requirements were noted in the specification for silt fence. Geogrid for soil applications is not listed in the specifications.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	604.2.4 (2007)	Woven or nonwoven, Classes 2 or 3	AASHTO M288	Yes	Very good
Bank Protection/ Erosion Control	604.2.3 (2007)	Woven or nonwoven, no woven slit film, Classes 1 or 2	AASHTO M288	No	Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	604.2.5 (2007)	Woven or nonwoven, Class 1	AASHTO M288	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	604.2.2 (2007)	Woven or nonwoven, no flat tape-like character, Classes 2 or 3	AASHTO M288	Yes	Very good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	604.2.1, 603 (2007)	Woven or nonwoven, Class 2	AASHTO M288	No	Good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-31. Geosynthetic Specification Summary—New York

State	New York				
The material requirements for geotextiles are listed in Section 737 of the state specifications and the construction requirements are listed in Section 207. This is a thorough specification that follows old M288 classes A, B, and C, but has requirements that can compare to other specifications. Geogrid is included in the MSE wall specification, Section 554. It also includes requirements for geocomposite drain materials.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	737-01B, 207 (9/5/13)	Any type of geotextile structure, Class 2	New York DOT based slightly on AASHTO M288	No	Good
Bank Protection/ Erosion Control	737-01A and D, 207 (9/5/13)	Bedding – Combination Monofilament/Fibrillated Yarn and Monofilament – Woven, Slope Protection – Needle-punched nonwoven	New York DOT based slightly on AASHTO M288	No	Very good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	737-01E, 207 (9/5/13)	Any type of geotextile structure, Class 1	New York DOT based slightly on AASHTO M288	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	737-01C, 207 (9/5/13)	Non-woven, Classes A, B, and C	New York DOT based slightly on AASHTO M288	No	Very good
Wall Drains	737-04, 207 (9/5/13)	Impermeable cores with 2-side flow, permeable with 1-side flow	New York DOT	No	Average
Edge Drains	737-06, 207 (9/5/13)	Core wrapped with drainage geotextile	New York DOT	No	Good
Silt Fence	737-01G, 207 (9/5/13)	Any type of geotextile structure	New York DOT based slightly on AASHTO M288	Yes, based on post spacing	Good
Geogrid	737-07 (9/5/13)	Does not state	AASHTO Specifications for Highway Bridges	No	Poor

(1) Rated by the Research Team

Table E-32. Geosynthetic Specification Summary—North Carolina

State	North Carolina				
The material requirements for geosynthetics are listed in Section 1056 of the state specifications. The requirements for five types of fabric are listed in one table, Type 1 – shoulder drain, Type 2 – under rip rap, Type 3 – temporary silt fence, Type 4 – soil stabilization, and Type 5 – temporary MSE walls. Another specification for geocomposite wall drain is also included. Sections 270 and 275 provide installation details for subgrade stabilization and rock plating. Although the specification refers to NTPEP and AASHTO M288 for evaluation, the specifications do not follow AASHTO M288.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	1056-4 Type 2, 275 (2012)	Woven or nonwoven	AASHTO M288 modified, NTPEP tested	No	Very good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	1056-4 Type 4, 270 (2012)	Woven or nonwoven	AASHTO M288 modified, NTPEP tested		Very good
MSE Walls	1056-4 (2012)	Woven or nonwoven	AASHTO M288 modified, NTPEP tested		Good
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	1056-4 Type 1 (2012)	Woven or nonwoven	AASHTO M288 modified, NTPEP tested		Very good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	1056-4 Type 3 (2012)	Woven or nonwoven	AASHTO M288 modified, NTPEP tested		Average
Geogrid	N/A				

(1) Rated by the Research Team

Table E-33. Geosynthetic Specification Summary—North Dakota

State	North Dakota				
The material requirements for geotextile fabrics are presented in Section 858 of the state specifications. Section 858 has a large table with the physical requirements for eight types of fabric. AASHTO M288 is not referred to in the specification. The puncture requirement uses the old test method. Section 708 gives installation and material requirements for silt fence and fabric under the rock for construction entrances. Section 709 gives the installation requirements for all types of applications such as separation, filter for underdrains, filter for riprap and reinforcement. A geogrid specification was not found.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	858.01A, 709 (2008)	Nonwoven, S1 and S2	North Dakota DOT Needs updating	No	Good
Bank Protection/ Erosion Control	858.01A, 709 (2008)	Woven or nonwoven, must meet permittivity, RR	North Dakota DOT Needs updating	No	Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	858.01A, 709 (2008)	Permittivity for D2 appears incorrect, D3 and D4 are for fabric socks	North Dakota DOT Needs updating	No	Good except for D2
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	N/A				
Geogrid	N/A				

(1) Rated by the Research Team

Table E-34. Geosynthetic Specification Summary—Ohio

State	Ohio				
The material requirements for geotextiles are listed in Section 712.09 of the state specifications. Type A fabric is for underdrains and slope drains, Type B fabric is for filter fabric for rock channel protection, Type C fabric is for sediment fences, and Type D fabric is for subgrade-base separation or stabilization. The specification refers to NTPEP evaluation for acceptance or approval of each type. The specifications do not follow AASHTO M288 except for Type E fabric. Although the use is not specified, it is apparently paving fabric since that is the AASHTO M288 specification that is referred to. There is also a prefabricated edge drain specification (Section 712.10). The placement requirements for geotextile separation or stabilization are listed in Section 204. This includes the design method for subgrade stabilization with geotextiles.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	712.09, Type D (2010)	Woven or nonwoven	Ohio DOT, accepted based on NTPEP testing	No	Very good
Bank Protection/ Erosion Control	712.09, Type B (2010)	Woven or nonwoven	Ohio DOT, accepted based on NTPEP testing	No	Very good
Paving Fabric	712.09, Type B (2010)	Nonwoven	AASHTO M288, Section 10, Table 8, NTPEP tested	No	Good
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	712.09, Type D (2010)	Woven or nonwoven	Ohio DOT, accepted based on NTPEP testing	No	Very good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	712.09, Type A (2010)	Woven or nonwoven	Ohio DOT, accepted based on NTPEP testing	Yes	Very good
Wall Drains	N/A				
Edge Drains	712.10	Polymeric core wrapped in drainage fabric	Ohio DOT		Very good
Silt Fence	712.09, Type C (2010)	Woven or nonwoven	Ohio DOT, accepted based on NTPEP testing		Very good

Table E-34. Geosynthetic Specification Summary—Ohio (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Geogrid	SS 861.02 (7/19/13)	Geosynthetic material formed by a regular network of integrally connected elements	Ohio DOT	No	Good

[(1)] Rated by the Research Team

Table E-35. Geosynthetic Specification Summary—Oklahoma

State	Oklahoma				
The material requirement for geotextiles is listed in state specification Section 712, Construction Fabrics. This specification completely refers to AASHTO M288 for bank protection fabric, subgrade reinforcement, base course separation, and silt fence. Following this is a specification for geogrid reinforcement of pavement structures. The requirements for two types are listed. The installation specifications for separator fabric for base and geosynthetic reinforcement (geotextile or geogrid) are presented in Sections 325 and 326, respectively.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	712.05, 325 (2009)	Separation Geotextile Property Requirements	AASHTO M288	No	Good
Bank Protection/ Erosion Control	712.02 (2009)	Permanent Erosion Control Geotextile Requirements	AASHTO M288	No	Good
Paving Fabric	712.01 (2009)	Paving fabric requirements	AASHTO M288	No	Good
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	712.04, 326 (2009)	Stabilization Geotextile Property Requirements	AASHTO M288		Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	712.03 (2009)	Subsurface Drainage Geotextile Requirements, Table 2, 15 to 50% passing the No. 200 sieve	AASHTO M288	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	712.06 (2009)	Temporary Silt Fence Requirements for unsupported, <50% elongation	AASHTO M288	No	Good
Geogrid	712.07, 326, Types 1 and 2 (2009)	Long-chain polymeric polymers formed into a dimensionally stable network	Oklahoma DOT	No	Very good

(1) Rated by the Research Team

Table E-36. Geosynthetic Specification Summary—Oregon

State	Oregon				
The material requirements for geotextiles are listed in state specification Section 02320, in one large table, with requirements for drainage geotextile, Types 1 and 2, Riprap Geotextile, Types 1 and 2, sediment fence geotextile, supported and unsupported (two types), subgrade geotextile, embankment geotextile, and pavement overlay geotextile. The puncture test utilizes the old test method. The specifications do not follow AASHTO M288. Oregon has its own test method for asphalt retention. They have a geogrid specification but no physical requirements are given. The requirements for geosynthetic installation are presented in Section 00350, which is fairly comprehensive. They also include Section 00331 on subgrade stabilization. Section 00430 covers the installation of subsurface drains. Section 00435 gives the material and installation requirements for prefabricated vertical drains (wall drains). Subsection 00641.43 gives the requirements for placing aggregate base or subbase on geotextile.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	02320-1 Table, 00350 (2008)	Woven or nonwoven, subgrade geotextile	Oregon DOT, needs updating	No	Good
Bank Protection/ Erosion Control	02320-1 Table, 00350 (2008)	Woven or nonwoven, riprap geotextile Types 1 or 2, slit film not acceptable	Oregon DOT, needs updating	No	Good
Paving Fabric	02320-1 Table, 00350 (2008)	Woven or nonwoven, pavement overlay geotextile, slit film not acceptable	Oregon DOT, needs updating	No	Good
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	02320-1 Table, 00331 (2008)	Woven or nonwoven, subgrade geotextile	Oregon DOT, needs updating	No	Good
MSE Walls	Special Provision				
Reinforced Slopes	02320-1 Table, 00350 (2008)	Woven or nonwoven, embankment geotextile	Oregon DOT, needs updating	No	Good
Retaining Walls	N/A				
Drainage	02320-1 Table, 00350 (2008)	Woven or nonwoven, drainage geotextile Types 1 or 2, slit film not acceptable	Oregon DOT, needs updating	No	Good
Wall Drains	004235.12 (2008)	Continuous plastic core with structure to promote drainage, non-woven geotextile	Oregon DOT	No	Average

Table E-36. Geosynthetic Specification Summary—Oregon (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Edge Drains					
Silt Fence	02320-1 Table (2008)	Woven or nonwoven, sediment fence geotextile, supported and unsupported	Oregon DOT, needs updating	No	Good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-37. Geosynthetic Specification Summary—Pennsylvania

State	Pennsylvania				
The material requirements for geotextiles are listed in Section 735 of the state specifications. The physical requirements are presented in a Table for subsurface drainage, erosion control, sediment control (silt fence), separation, stabilization and reinforcement. There appear to be some deficiencies in the requirements and the puncture test method is out of date.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	735, Table A (2000)	Needle-punched nonwoven, Class 4, Type A	Pennsylvania DOT, needs updating	No	Average Too complex
Bank Protection/ Erosion Control	735, Table A (2000)	Woven or nonwoven, Class 2, Types A or B	Pennsylvania DOT, needs updating	No	Average Too complex
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	735, Table A (2000)	Woven, Class 4, Type B	Pennsylvania DOT, needs updating	No	Average
MSE Walls	N/A				
Reinforced Slopes	735, Table A (2000)	Woven, Class 4, Type C	Pennsylvania DOT, needs updating	No	Average
Retaining Walls	N/A				
Drainage	735, Table A (2000)	Woven or nonwoven, Class 1	Pennsylvania DOT, needs updating	No	Average Too complex
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	735, Table A (2000)	Woven or nonwoven, Class 3, Types A and B	Pennsylvania DOT, needs updating		Average Too complex
Geogrid	N/A				

(1) Rated by the Research Team

Table E-38. Geosynthetic Specification Summary—Rhode Island

State	Rhode Island				
Rhode Island has no specification for geotextiles or geogrids. The APL shows the products that have been approved for use. According to the APL, the products are evaluated using the AASHTO M288 specification for the different applications.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A	Geotextiles on Approved Materials List	Tested in accordance with AASHTO M288	N/A	N/A
Bank Protection/ Erosion Control	N/A	Geotextiles on Approved Materials List	Tested in accordance with AASHTO M288	N/A	N/A
Paving Fabric	N/A	Paving Fabric on Approved Materials List	No Test Criteria specified	N/A	N/A
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	N/A	Geotextiles on Approved Materials List	Tested in accordance with AASHTO M288	N/A	N/A
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	N/A	Geotextiles on Approved Materials List	Tested in accordance with AASHTO M288	N/A	N/A
Geogrid	N/A	Geogrids on Approved Materials List	No Test Criteria specified	N/A	N/A

(1) Rated by the Research Team

Table E-39. Geosynthetic Specification Summary—South Carolina

State	South Carolina				
The requirements for erosion control and slope protection fabrics are listed in Section 804.2.11 of the state specifications. Section 815.2.5.2 gives the requirements for silt fence fabric. In Section 815 there is a host of specifications for erosion control on slopes, mostly for landscape utilization. There are supplemental specifications for drainage fabric and separation fabric, but these are old and outdated. There is no geogrid specification.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	1992 Supplemental Separation	85% by weight polyolefins or polyesters, woven or nonwoven	South Carolina DOT Needs updating	Yes	Average
Bank Protection/ Erosion Control	804.2.11 (2007)	None listed for Classes 1 and 2, Types A, B, C and D piping resistance based on soil gradation	South Carolina DOT, also AASHTO M288, needs updating	Yes	Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	1991 Supplemental Drainage Filtration	Classes 1 or 2	South Carolina DOT Needs updating	Yes	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	815.2.5.2 (2007)	Self-supporting only	South Carolina DOT	No	Average
Geogrid	N/A				

(1) Rated by the Research Team

Table E-40. Geosynthetic Specification Summary—South Dakota

State	South Dakota				
The requirements for geotextiles and geomembrane are presented in a table in Section 831 of the state specifications. The table gives requirements for drainage, separation, silt fence, MSE wall fabric and geomembrane. The puncture and burst strength requirements have not been updated. The Type A fabric specification is very weak. Drainage fabric with a fairly low strength is used below riprap bank protection. There is no geogrid specification.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	831.1 A (2004)	Woven or nonwoven, each with different requirements	South Dakota, needs updating	No	Average
Bank Protection/ Erosion Control	831.1 A (2004)	Type B drainage fabric, too low strength for below riprap	South Dakota, needs updating	No	Poor
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	831.1 A (2004)	No type specified, but limited elongation	South Dakota, needs updating	No	Good
Reinforced Slopes	831.1 A (2004)	No type specified, but limited elongation	South Dakota, needs updating	No	Good
Retaining Walls	N/A				
Drainage	831.1 A (2004)	Types A or B depending on application, Type A not good	South Dakota, needs updating	No	Average
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	831.1 A (2004)	No type specified, permittivity is high for this application	South Dakota, needs updating	No	Average
Geogrid	N/A				

(1) Rated by the Research Team

Table E-41. Geosynthetic Specification Summary—Tennessee

State	Tennessee				
The specifications for geotextiles are presented in state specification Section 918.27, which refers to AASHTO M288 for some of the requirements for subsurface drainage, erosion control and stabilization. Requirements are given for permeability and AOS. Other fabrics are specified by special provision. There is no specification for geogrids. The installation requirements for geotextiles are given in Section 740, but are not very specific or thorough. The 2006 supplemental specification for Subsection 918.27 replaced the entire subsection and referred to the QPL for the approved fabric to be used or as called out on the project plans. As a result, no material specification actually remained. No geogrid specification was found and no geogrids were on the QPL. They have a special provision for geogrid used for reinforced soil slopes.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	918.27 (2006)	Geotextile (Type III), Tables 1 and 5, 15% to 50% passing 0.075 mm	AASHTO M288 Erosion Control modified	No	Poor No class given
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	918.27 (2006)	Geotextile (Type IV), Tables 1 and 4, Class 1, elongation less than 50%	AASHTO M288 modified	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	918.27 (2006)	Geotextile (Type I), Tables 1 and 2, Class 2, 15% to 50% passing 0.075 mm	AASHTO M288 Subsurface Drainage modified	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	N/A				
Geogrid	N/A				

(1) Rated by the Research Team

Table E-42. Geosynthetic Specification Summary—Texas

State	Texas				
The requirements for geosynthetics used by Texas DOT are listed in specifications that are called Texas Materials Specifications, which are separate from the Texas DOT standard specifications. DMS-6200 is for filter fabric utilized for drainage, separation and bank protection purposes, Types 1 and 2. No puncture requirement is noted. The requirements for paving fabric are given in DMS 6220. The fabric is utilized more for sealing the pavement structure than for crack control. DMS 6210 is for a vertical moisture barrier or geomembrane. DMS 6230 is for silt fence fabric. DMS 6240 is a specification for geogrid base/embankment reinforcement, and there are two types. DMS 6250 was for geogrid/fabric composite, but had been deleted. DMS 6260 is for a reinforced fabric underseal for use under overlays to seal significant longitudinal or transverse cracks in asphalt or concrete. DMS 6270 is for geogrid beneath pavement structure to prevent shrinkage cracks and the subgrade soils from affecting the overlying pavement structure. This is probably used where the soil has a high shrinkage potential due to the high fat clay content.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	DMS-6200 (May 2010)	Non-woven, Type 1 filter fabric	Texas DOT	No	Good
Bank Protection/ Erosion Control	DMS-6200 (May 2010)	Non-woven, Type 2 filter fabric	Texas DOT	No	Good
Paving Fabric	DMS 6220 (May 2010)	Non-woven fabric, fabric underseal	Texas DOT	No	Good
Pavement System Base Reinforcement	DMS 6240 (May 2010)	Synthetic planar structure, integrally connected polymeric tensile elements with apertures, Types 1 and 2	Texas DOT	No	Very good
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	DMS 6240 (May 2010)	Synthetic planar structure, integrally connected polymeric tensile elements with apertures, Types 1 and 2	Texas DOT	No	Very good
Retaining Walls	DMS-6200 (May 2010)	Non-woven, Type 1 filter fabric	Texas DOT	No	Good
Drainage	DMS-6200 (May 2010)	Non-woven, Type 1 filter fabric	Texas DOT	No	Good
Wall Drains	N/A				
Edge Drains	N/A				

Table E-42. Geosynthetic Specification Summary—Texas (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Silt Fence	DMS 6230 (May 2010)	Woven geotextile fabric	Texas DOT	No	Good
Geogrid	DMS 6240 (May 2010)	Synthetic planar structure, integrally connected polymeric tensile elements with apertures, Types 1 and 2	Texas DOT	No	Very good

(1) Rated by the Research Team

Table E-43. Geosynthetic Specification Summary—Utah

State	Utah				
The requirements for geotextiles are presented in Section 02075. The specifications generally refer to AASHTO M288 for the different applications such as erosion control, drainage, separation, stabilization, and weed control. Installation requirements for these fabrics are included in this specification also. Silt fence requirements are given in Section 01571. Asphalt overlay fabric requirements (AASHTO M288) and installation requirements are presented in Section 02078. There are two supplemental specifications for geogrid, one for subgrade stabilization and one for base reduction, 02072S and 02073S. Utah has a usage protocol for using geogrids for subgrade stabilization or base reinforcement.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	02075 2.4 (2012)	Class 1 fabric with an apparent opening size of 0.60 mm max	AASHTO M288	No	Very good
Bank Protection/ Erosion Control	02075 2.2 (2012)	None	AASHTO M288	No	Good
Paving Fabric	02078 (2012)	None	AASHTO M288	No	Very good
Pavement System Base Reinforcement	02073S (2012)	Geogrid base reduction, Types 1 and 2, punched and drawn	Manufacturer specifications	No	Very good
Pavement System Subgrade Stabilization	02075 2.5 (2012)	Class 1 fabric with an apparent opening size of 0.43 mm max	AASHTO M288	No	Very good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	02075 2.3 (2012)	Non-woven geotextile	AASHTO M288	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	01571 (2012)	Temporary silt fence	AASHTO M288	No	Good
Geogrid	02072S (2012)	Geogrid Sub-Grade Stabilization, Types 1 and 2, punched and drawn	Manufacturer specifications	No	Very good

(1) Rated by the Research Team

Table E-44. Geosynthetic Specification Summary—Vermont

State	Vermont				
The physical requirements for geotextiles are given in state specification Section 720 and the installation requirements are given in Section 649. Vermont uses geotextiles for separation, under railroad ballast, under stone fill, for underdrains, silt fence, and as a filter curtain. They have their own requirements for AOS and permittivity, so it does not completely follow AASHTO M288. Vermont does not have a standard geogrid specification, but there are several special provisions involving geogrids in various applications.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	Table 720.04A, 649.04 (5) (2011)	Woven or nonwoven, Class 2	Vermont DOT, but follows AASHTO M288	No	Very good
Bank Protection/ Erosion Control	Table 720.04A, 649.04 (4) (2011)	Woven or nonwoven, Class 1, woven slit film excluded	Vermont DOT, but follows AASHTO M288	No	Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	Table 720.04A 649.04 (5)(2011)	Woven or nonwoven, Class 1, woven slit film excluded	Vermont DOT, but follows AASHTO M288	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	Table 720.04A, 649.04 (3) (2011)	Nonwoven only, slit film not permitted	Vermont DOT	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	Table 720.04A, 649.04 (6) (2011)	Unsupported silt fence, woven only	Vermont DOT, but follows AASHTO M288	No	Very good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-45. Geosynthetic Specification Summary—Virginia

State	Virginia				
The requirements for geotextiles in Virginia are listed in Section 245 of the state specifications. The specification primarily utilizes AASHTO M288 for the different applications, but has its own requirements for some of the properties such as permittivity and AOS. This is a good specification that can be very useful for this research effort. There are many application specifications within the 2007 standard specification. There is also a supplemental specification published in April 2013 that modifies the material specification Section 245. Virginia is involved with NTPEP geotextile evaluation and refers to NTPEP test results in their specification. They are in the process of updating their specification. They use geogrid in special cases, but not as part of the design of the pavement section, and have done no testing or research on that. There is no geogrid standard specification.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	N/A				
Bank Protection/ Erosion Control	245.03 (b) (2007)	Separation, Table 3, Table 1, Class 2	AASHTO M288 modified	No	Average
Paving Fabric	245.03 (i) (2007)	Geotextile paving fabric and pavement reinforcing mat	AASHTO M288 and ASTM D7239, Type 1	No	Good
Pavement System Base Reinforcement					
Pavement System Subgrade Stabilization	245.03 (d) (2007)	Table 1, Class 3, AOS max of No. 20 sieve, too low strength, for embankment stabilization, Class 1	AASHTO M288 modified	No	Poor
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	245.03 (c) (2007)	Nonwoven, Table 1, Class 3, 0.5 sec-1 permittivity, AOS max of No. 50 sieve	AASHTO M288 modified	No	Very good
Wall Drains	245.03 (f) (2007)	Polymeric drainage core encased in a nonwoven filter fabric envelope	Virginia DOT	No	Good
Edge Drains	245.03 (e) (2007)	Polymeric drainage core encased in a nonwoven filter fabric envelope	Virginia DOT	No	Good

Table E-45. Geosynthetic Specification Summary—Virginia (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Silt Fence	245.03 (a) (2007)	Table 7 of AASHTO M288 except and as modified	AASHTO M288 modified	No	Very good
Geogrid	N/A				

[(1)] Rated by the Research Team

Table E-46. Geosynthetic Specification Summary—Washington

State	Washington
The physical requirements for Construction Geosynthetics are listed in Section 9-33 of the state specifications, which includes underground drainage – low and moderate survivability, separation, soil stabilization, permanent erosion control – moderate and high survivability, ditch lining, temporary silt fence, permanent geosynthetic retaining wall, temporary geosynthetic retaining wall, and prefabricated drainage mat. There are eight tables giving properties for the different applications. Section 2-12, Construction Geosynthetics, gives the requirements for installation of the different types of geosynthetics. The requirements for geogrids are provided in Table 10 in the project special provisions. Geogrid is also mentioned in Section 6-13, Structural Earth Walls, and Section 6-14, Geosynthetic Retaining Wall, as part of the submittal for MSE wall soil reinforcement. However, no properties are given for it other than what the wall contractor is utilizing in their design or as called out in the project special provisions, Table 10. Chapter 630 of the Materials Design Manual gives design guidance for geosynthetic utilization. The portion for Silt Fence is very thorough.	

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Separation	N/A				
Bank Protection/ Erosion Control	245.03 (b) (2007)	Separation, Table 3, Table 1, Class 2	AASHTO M288 modified	No	Average
Paving Fabric	245.03 (i) (2007)	Geotextile paving fabric and pavement reinforcing mat	AASHTO M288 and ASTM D7239, Type 1	No	Good
Pavement System Base Reinforcement					
Pavement System Subgrade Stabilization	245.03 (d) (2007)	Table 1, Class 3, AOS max of No. 20 sieve, too low strength, for embankment stabilization, Class 1	AASHTO M288 modified	No	Poor
MSE Walls	N/A				

Table E-46. Geosynthetic Specification Summary—Washington (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	245.03 (c) (2007)	Nonwoven, Table 1, Class 3, 0.5 sec-1 permittivity, AOS max of No. 50 sieve	AASHTO M288 modified	No	Very good
Wall Drains	245.03 (f) (2007)	Polymeric drainage core encased in a nonwoven filter fabric envelope	Virginia DOT	No	Good
Edge Drains	245.03 (e) (2007)	Polymeric drainage core encased in a nonwoven filter fabric envelope	Virginia DOT	No	Good
Silt Fence	245.03 (a) (2007)	Table 7 of AASHTO M288 except and as modified	AASHTO M288 modified	No	Very good
Geogrid	N/A				

(1) Rated by the Research Team

Table E-47. Geosynthetic Specification Summary—West Virginia

State	West Virginia
West Virginia has a specification for base reinforcement geogrid (Section 206). The specification includes a table giving properties for two types of geogrid. West Virginia obviously has a design process for increased structural coefficient for the base course based on use of the geogrid since they require geogrids that do not meet the specifications to produce in-ground testing that shows the benefit of the alternative geogrid. A report exists (RP-98) which involves the benefit of using geogrid in the pavement structure. The requirements for geotextiles are listed in the 2013 supplemental specifications, 715-11. The specification calls out requirements for AASHTO M288, but has some requirements such as permittivity and AOS specified for subsurface drainage, AASHTO M288 for silt fence fabric; AASHTO M288, Table 7, Class 1 for erosion control; AASHTO M288 Section 9 for paving fabric; AASHTO M288, Table 7, Class 2 for separation; and AASHTO M288, Table 7, Class 1 for stabilization. A supplemental specification for prefabricated edge drains, Section 715-10, is also included.	

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Separation	715.11.8 (2013)	AASHTO M288, Section 7, Class 2	AASHTO M288, Needs Updating	No	Poor

Table E-47. Geosynthetic Specification Summary—West Virginia (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Bank Protection/ Erosion Control	715.11.6 (2013)	AASHTO M288, Section 7, Class 1	AASHTO M288, Needs Updating	No	Poor
Paving Fabric	715.11.7 (2013)	AASHTO M288, Section 9	AASHTO M288, Needs Updating	No	Poor
Pavement System Base Reinforcement	715.11.9 (2013)	AASHTO M288, Section 7, Class 1	AASHTO M288, Needs Updating	No	Poor
Pavement System Subgrade Stabilization					
MSE Walls					
Reinforced Slopes					
Retaining Walls					
Drainage	715.11.4 (2013)	AASHTO M288, Section 7, Class 2, permittivity min 0.2 sec-1, AOS No. 60 maximum	AASHTO M288, Needs Updating	No	Poor
Wall Drains					
Edge Drains	715.10 (2013)	Polymeric drainage core encased in an engineering fabric envelope	West Virginia DOT	No	Very good
Silt Fence	715.11.5 (2013)	AASHTO M288, Section 8	AASHTO M288, Needs Updating	No	Poor
Geogrid	206.3.3 (2010)	Biaxial geogrid, Types 1 and 2	West Virginia DOT	No	Very good

(1) Rated by the Research Team

Table E-48. Geosynthetic Specification Summary—Wisconsin

State	Wisconsin				
Wisconsin has a specification for geotextiles (Section 645), which includes material and construction specifications for subgrade aggregate separation normal and modified, marsh stabilization, drainage filtration with three levels of AOS and permittivity, subgrade reinforcement, riprap, heavy riprap, and embankment stabilization. Wisconsin does not follow AASHTO M288 and uses the old puncture test method. There is no specification for pavement fabric or geogrid.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	645.2.2 (2014)	Type SAS, woven or nonwoven	Wisconsin DOT, needs updating	No	Very good
Bank Protection/ Erosion Control	645.2.6 or 7 (2014)	Type R or HR, woven or nonwoven, riprap or heavy riprap	Wisconsin DOT, needs updating	No	Very good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	645.2.3 or 5 (2014)	Type MS or SR, woven or nonwoven, must meet special provisions	N/A	No	Good
MSE Walls	N/A				
Reinforced Slopes	645.2.9	Type ES, woven or nonwoven, must meet special provisions	N/A	No	Good
Retaining Walls	N/A				
Drainage	645.2.4 (2014)	Type DF, woven or nonwoven, Schedule A, B, or C, no slit film woven	Wisconsin DOT, needs updating	No	Very good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	N/A				
Geogrid	N/A				

(1) Rated by the Research Team

Table E-49. Geosynthetic Specification Summary—Wyoming

State	Wyoming				
Wyoming has a specification for geotextiles, membrane and fabrics (Section 805). The specification includes a table that has physical properties specified for drainage and filtration fabric, erosion control, silt fence, separation and stabilization (Non-Woven), embankment and retaining wall reinforcement, impermeable plastic membrane, and subgrade reinforcement. There is a separate specification for paving fabric, including specifications for glass fiber reinforced paving fabric.					
Geosynthetic Applications/ Uses Identified	**Specification Number (Date)**	**Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)**	**Basis for Specification (e.g., AASHTO M288-06 (2011))**	**Design Guidelines within Specification?**	**Specification Rating[(1)]**
Separation	Table 805.2-1 (2010)	Woven or nonwoven, 95% by weight of polyolefins or polyesters	Wyoming DOT, needs updating	No	Good
Bank Protection/ Erosion Control	Table 805.2-1 (2010)	Woven or nonwoven, 95% by weight of polyolefins or polyesters	Wyoming DOT, needs updating	No	Good
Paving Fabric	Table 805.3-1	Paving fabric and grid composite	Wyoming DOT, based on Manufacturer's spec	No	Unique
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	Table 805.2-1 (2010)	Woven or nonwoven, 95% by weight of polyolefins or polyesters	Wyoming DOT, needs updating	No	Good
MSE Walls	N/A				
Reinforced Slopes	Table 805.2-1 (2010)	Woven or nonwoven, 95% by weight of polyolefins or polyesters	Wyoming DOT, needs updating	No	Good
Retaining Walls	Table 805.2-1 (2010)	Woven or nonwoven, 95% by weight of polyolefins or polyesters	Wyoming DOT, needs updating	No	Good
Drainage	Table 805.2-1 (2010)	Woven or nonwoven, 95% by weight of polyolefins or polyesters	Wyoming DOT, needs updating	No	Good
Wall Drains	N/A				
Edge Drains	N/A				
Silt Fence	Table 805.2-1 (2010)	Woven or nonwoven, 95% by weight of polyolefins or polyesters	Wyoming DOT, needs updating	No	Good

Table E-49. Geosynthetic Specification Summary—Wyoming (continued)

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating[(1)]
Geogrid	N/A				

[(1)] Rated by the Research Team

APPENDIX F: SUMMARIES OF THE FHWA-CFLHD-USFS AND THE UFGS SPECIFICATIONS

Table F-1. FHWA FP-03 [1]/ CFLHD / USFS Geosynthetic Specifications

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating [2]
Separation	714.01 (2003) Type II (A-C)	Long-chain polymers, 95 percent polyolefins or polyesters	Follows AASHTO by values chosen in tables, needs updating	No	Good
Bank Protection/ Erosion Control	714.01 (2003) Type IV (A-F)	Long-chain polymers, 95 percent polyolefins or polyesters	Follows AASHTO by values chosen in tables, needs updating	No	Good
Paving Fabric	714.01 (2003) Type VI	Long-chain polymers, 95 percent polyolefins or polyesters	Follows AASHTO by values chosen in tables, needs updating	No	Good
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	714.01 (2003) Type III (A-B)	Long-chain polymers, 95 percent polyolefins or polyesters	Follows AASHTO by values chosen in tables, needs updating	No	Good
MSE Walls	N/A				
Reinforced Slopes	N/A				
Retaining Walls	N/A				
Drainage	714.01 (2003) Type I (A-F)	Long-chain polymers, 95 percent polyolefins or polyesters	Follows AASHTO by values chosen in tables, needs updating	No	Good
Wall Drains	714.02 (2003)	Long-chain synthetic polymer drainage core with geotextile encapsulation	FHWA spec	No	Average
Edge Drains	714.02 (2003)	Long-chain synthetic polymer drainage core with geotextile laminated on one side	FHWA spec	No	Average
Silt Fence	714.01 (2003) Type V (A-C)	Long-chain polymers, 95 percent polyolefins or polyesters	Follows AASHTO by values chosen in tables, needs updating	No	Good
Geogrid	N/A				

(1) FP denotes Standard Specifications for the Construction of Roads and Bridges on Federal Highway Projects

(2) Research Team specifications ratings definitions:

Poor: The specification is out of date, insufficient to adequately define the material, has material requirements that cannot be met, no installation requirements, and as such would not be a good resource.

Average: The specification is out of date, but otherwise is somewhat reasonable, many times does not include much in the way of installation requirements, and is generally limited.

Good: The specification has all the materials requirements typically needed, is limited on installation requirements, may be somewhat out of date, but is generally a fairly comprehensive specification.

Very good: The specification is up to date, comprehensive, generally has good installation aspects, and could be a model specification depending on the type of specification chosen.

Table F-2. UFGS Geosynthetic Specifications

Geosynthetic Applications/ Uses Identified	Specification Number (Date)	Geosynthetic Type(s) Specified (e.g., materials, manufacturing processes, classes)	Basis for Specification (e.g., AASHTO M288-06 (2011))	Design Guidelines within Specification?	Specification Rating [1]
Separation	Section 31 05 19 (2008)	Nonwoven	Follows AASHTO M288 with values chosen, needs updating	Some	Good
Bank Protection/ Erosion Control	Section 31 05 22 (2008)	Woven or nonwoven, various strength requirements depending on application	Unified Facilities Guide Specifications, filter spec	Some	Good
Paving Fabric	N/A				
Pavement System Base Reinforcement	N/A				
Pavement System Subgrade Stabilization	N/A				
MSE Walls	N/A				
Reinforced Slopes	Section 31 05 21 (2008)	Geogrid, dimensionally stable, polyethylene, polyester or other	Strength values dependent upon design	No	Good
Retaining Walls	N/A				
Drainage	Section 31 05 19 (2008)	Nonwoven	Follows AASHTO M288 with values chosen, needs updating	Some	Good
Wall Drains	Section 31 05 20 (2008)	Polyethylene geonet, with nonwoven geotextile fabric	Unified Facilities Guide Specifications	No	Good
Edge Drains	N/A				
Silt Fence	N/A				
Geogrid	Section 31 05 21 (2008)	Dimensionally stable, polyethylene, polyester or other	Strength values dependent upon design	No	Good

(1) Research Team specifications ratings definitions:

Poor: The specification is out of date, insufficient to adequately define the material, has material requirements that cannot be met, no installation requirements, and as such would not be a good resource.

Average: The specification is out of date, but otherwise is somewhat reasonable, many times does not include much in the way of installation requirements, and is generally limited.

Good: The specification has all the materials requirements typically needed, is limited on installation requirements, may be somewhat out of date, but is generally a fairly comprehensive specification.

Very good: The specification is up to date, comprehensive, generally has good installation aspects, and could be a model specification depending on the type of specification chosen.

APPENDIX G: SUMMARY OF SELECT STATE AND FEDERAL PAVEMENT FABRIC SPECIFICATIONS

Table G-1. Select State and Federal Pavement Fabric Specifications (1)

Specification	Minimum Grab Strength (N) ASTM D4632	Minimum Ultimate Elongation (N) ASTM D4632	Minimum Mass per Unit Area (gm/m^2) ASTM D5261	Minimum Asphalt Retention (l/m^2) ASTM D6140	Minimum Melting Point (°C) ASTM D276	Fabric Thickness (mils) ASTM D461
AASHTO, Alaska	450	≥50%	140	Saturate Fabric	150	-
FHWA Type VI	500	≥50%	140	0.90	150	-
California	534 (100 lb)	≥50%	139 (4.1 oz/ yd^2)	0.90 (0.2 gal/ yd^2)	163 (325°F)	-
Idaho	-	-	-	-	-	-
Montana	-	-	-	-	-	-
Oregon	445 (100 lb)	≥50%	-	0.90 (2.8 oz/ft^2)	149 (300°F)	-
Washington	-	-	-	-	-	-
ADOT	356 (80 lb)	≥50%	119-203 (3.5-6.0 oz/yd^2)	0.90 (0.2 gal/ yd^2)	149 (300°F)	25-100

(1) Units: N-Newtons; gm–grams; m^2 square meter; l-liter; °C-degrees Celsius; mils-thousandth of an inch; m^2 –square meter; lb-pounds; oz-ounce; yd^2 –square yard; gal-gallon; °F-degrees Fahrenheit; ft^2 –square foot

APPENDIX H: SUMMARY OF SELECT STATE AND FEDERAL SEPARATION GEOTEXTILE SPECIFICATIONS

Table H-1. Very High Survivability Separation Specifications [(1)]

AASHTO/ FHWA/ State DOT	Elongation (%) ASTM D4632	Minimum Grab Strength [N (lb)] ASTM D4632	Minimum Sewn Seam Strength [N (lb)] ASTM D4632	Minimum Tear Strength [N (lb)] ASTM D4533	Minimum Puncture Strength [N (lb)] ASTM D6241	Minimum Puncture Strength [N (lb)] ASTM D4833	Minimum Burst Strength [kPa (psi)] ASTM D3786	Minimum Permittivity (sec^{-1}) ASTM D4491	Maximum Apparent Opening Size [mm (Sieve)] ASTM D4751	Minimum UV Stability (%) ASTM D4355
Arizona Very High	Woven 13-115	1512 (340)	-	400 (90)	-	578 (130)	3447 (500)	0.07	0.11-0.60 (140-30)	70
	Nonwoven 45-115	1201 (270)	-	334 (75)	-	489 (110)	2965 (430)			

(1) Units: N-Newton; lb-pound; kPa-kilopascal; psi-pounds per square inch; sec-second; mm-millimeter

Table H-2. High Survivability Separation Specifications [1]

AASHTO/ FHWA/ State DOT	Elongation (%)	Minimum Grab Strength [N (lb)]	Minimum Sewn Seam Strength [N (lb)]	Minimum Tear Strength [N (lb)]	Minimum Puncture Strength [N (lb)]	Minimum Puncture Strength [N (lb)]	Minimum Burst Strength [kPa (psi)]	Minimum Permittivity (sec^{-1})	Maximum Apparent Opening Size [mm (Sieve)]	Minimum UV Stability (%)
	ASTM D4632	ASTM D4632	ASTM D4632	ASTM D4533	ASTM D6241	ASTM D4833	ASTM D3786	ASTM D4491	ASTM D4751	ASTM D4355
AASHTO Class 1	<50	1400 (315)	1260 (283)	500 (112)	2750 (618)	-	-	0.02	0.60(30)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (77)	1925 (433)	-	-			
FHWA Type II-A	<50	1400 (315)	1260 (283)	500 (112)	-	500 (112)	3500 (507)	0.02	0.60 (30)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (77)	-	350 (77)	1700 (247)			
Alaska Class 1	<50	1400 (315)	1260 (283)	500 (112)	2750 (618)	-	-	0.05	0.60 (30)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (77)	1925 (433)	-	-			
Idaho Type II	<50	1201 (270)	-	445 (100)	2669 (600)	-	-	0.02	0.21 (70)	-
	≥50	801 (180)	-	334 (75)	2002 (450)	-	-			
Idaho Type III	<50	1201 (270)	-	445 (100)	2669 (600)	-	-	0.7	-	-
	≥50	801 (180)	-	334 (75)	2002 (450)	-	-			
Montana High	<50	1400 (315)	1260 (283)	500 (112)	-	500 (112)	-	0.02	0.60 (30)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (77)	-	350 (77)	-			
Arizona High	Woven 13-115	1201 (270)	-	334 (75)	-	489 (110)	2965 (430)	0.07	0.11-0.60 (140-30)	70
	Nonwoven 45-115	889 (200)	-	222 (50)	-	334 (75)	2206 (320)			

(1) Units: N-Newton; lb-pound; kPa-kilopascal; psi-pounds per square inch; sec-second; mm-millimeter

Table H-3. Moderate Survivability Separation Specifications [1]

AASHTO/ FHWA/ State DOT	Elongation (%) ASTM D4632	Minimum Grab Strength [N (lb)] ASTM D4632	Minimum Sewn Seam Strength [N (lb)] ASTM D4632	Minimum Tear Strength [N (lb)] ASTM D4533	Minimum Puncture Strength [N (lb)] ASTM D6241	Minimum Puncture Strength [N (lb)] ASTM D4833	Minimum Burst Strength [kPa (psi)] ASTM D3786	Minimum Permittivity (sec^{-1}) ASTM D4491	Maximum Apparent Opening Size [mm (Sieve)] ASTM D4751	Minimum UV Stability (%) ASTM D4355
AASHTO Class 2	<50	1100 (247)	990 (223)	400 [2] (90)	2200 (495)	-	-	0.02	0.60(30)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	1375 (309)	-	-			
FHWA Type II-B	<50	1100 (247)	990 (223)	400 [3] (90)	-	400 (90)	2700 (392)	0.02	0.60 (30)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	-	250 (56)	1300 (189)			
Alaska Class 2	<50	1100(247)	990 (223)	400 [2] (90)	2200 (495)	-	-	0.05	0.60 (30)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	1375 (309)	-	-			
California Classes A,B,C	≥50	700 (157)	-	249 (56)	1379 (310)	-	-	A: 0.5 B: 0.2 C: 0.1	A: 0.42 (40) B: 0.25 (60) C: 0.21 (70)	70 @ 500 hours
Montana Moderate	<50	1100 (247)	990 (223)	400 (90)	-	400 (90)	-	0.02	0.60(30)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	-	250 (56)	-			
Washington	Woven <50	1112 (250)	979 (220)	356 (80)	2202 (495)	-	-	0.02	0.60 (30)	50 @ 500 hours
	Nonwoven ≥50	712 (160)	623 (140)	222 (50)	1379 (310)	-	-			
Arizona Moderate	Woven 13-115	889 (200)	-	222 (50)	-	334 (75)	2206 (320)	0.07	0.11-0.60 (140-30)	70
	Nonwoven 45-115	623 (140)	-	178 (40)	-	222 (50)	1448 (210)			

(1) Units: N-Newton; lb-pound; kPa-kilopascal; psi-pounds per square inch; sec-second; mm-millimeter

(2) The tear strength for woven monofilament geotextiles is 250 N (56 lb).

(3) The tear strength for woven monofilament geotextiles is 245 N (55 lb).

Table H-4. Low Survivability Separation Specifications [1]

AASHTO/ FHWA/ State DOT	Elongation (%)	Minimum Grab Strength [N (lb)]	Minimum Sewn Seam Strength [N (lb)]	Minimum Tear Strength [N (lb)]	Minimum Puncture Strength [N (lb)]	Minimum Puncture Strength [N (lb)]	Minimum Burst Strength [kPa (psi)]	Minimum Permittivity (sec^{-1})	Maximum Apparent Opening Size [mm (Sieve)]	Minimum UV Stability (%)
	ASTM D4632	ASTM D4632	ASTM D4632	ASTM D4533	ASTM D6241	ASTM D4833	ASTM D3786	ASTM D4491	ASTM D4751	ASTM D4355
AASHTO Class 3	<50	800 (180)	720 (162)	300 (67)	1650 (371)	-	-	0.02	0.60(30)	50 @ 500 hours
	≥50	500 (112)	450 (101)	180 (40)	990 (223)	-	-			
FHWA Type II-C	<50	800 (180)	720 (162)	300 (67)	-	300 (67)	2100 (305)	0.02	0.60 (30)	50 @ 500 hours
	≥50	500 (112)	450 (101)	180 (40)	-	180 (40)	950 (138)			
Alaska Class 3	<50	800 (180)	720 (162)	300 (67)	1650 (371)	-	-	0.05	0.60 (30)	50 @ 500 hours
	≥50	500 (112)	450 (101)	180 (40)	990 (223)	-	-			
Idaho Type I	<50	801 (180)	-	311 (70)	2224 (500)	-	-	0.02	0.60(30)	-
	≥50	512 (115)	-	178 (40)	1334 (300)	-	-			
Oregon	Woven <50	801 (180)	-	302 (68)	1650 (371)	-	-	0.05	0.60 (30)	50 @ 500 hours
	Nonwoven ≥50	503 (113)	-	182 (41)	992 (223)	-	-			
Arizona	Woven 13-115	623 (140)	-	178 (40)	-	222 (50)	1448 (210)	0.07	0.11-0.60 (140-30)	70
	Nonwoven 45-115	400 (90)	-	133 (30)	-	133 (30)	896 (130)			

(1) Units: N-Newton; lb-pound; kPa-kilopascal; psi-pounds per square inch; sec-second; mm-millimeter

APPENDIX I: SUMMARY OF SELECT STATE AND FEDERAL BANK PROTECTION FABRIC SPECIFICATIONS

Table I-1. Bank Protection/Erosion Control Specifications [1]

AASHTO/ FHWA/ State DOT	Elongation (%) ASTM D4632	Min. Grab Strength [N (lb)] ASTM D4632	Min. Sewn Seam Strength [N (lb)] ASTM D4632	Min. Tear Strength [N (lb)] ASTM D4533	Min. Puncture Strength [N (lb)] ASTM D6241	Min. Puncture Strength [N (lb)] ASTM D4833	Min. Burst Strength [kPa (psi)] ASTM D3786	in situ Soil Passing 0.0775 mm (%) AASHTO T88	Min. Permittivity (sec^{-1}) ASTM D4491	Max. AOS [mm (Sieve No.)] ASTM D4751	Min. UV Stability (%) ASTM D4355
AASHTO, Alaska Class 1 (For Non-WMF)	<50	1400 (315)	1260 (283)	500 (112)	2750 (618)	-	-	<15 15 to 50 >50	0.7 0.2 0.1	0.43 (40) 0.25 (60) 0.22 (70)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (79)	1925 (433)	-	-				
FHWA Types IV-A, IV-B, IV-C	<50	1400 (315)	1260 (283)	500 (112)	-	500 (112)	3500 (508)	-	A: 0.7 B: 0.2 C: 0.1	A: 0.43 (40) B: 0.25 (60) C: 0.22 (70)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (79)	-	350 (79)	1750 (254)				
California Class 10	≥50	1112 (250)	-	-	-	-	-	-	0.7	0.15-0.21 (100-70)	70 @ 500 hours
California Class 8	≥50	889 (200)	-	-	-	-	-	-	1.0	0.15-0.21 (100-70)	70 @ 500 hours
Idaho Type II - High	≥15	890 (200)	-	222 (50)	2669 (600)	-	-	-	0.5	-	-
Montana High Classes A,B,C	<50	1400 (315)	1260 (283)	500 (112)	-	500 (112)	-	<15 15 to 50 >50	A: 0.7 B: 0.4 C: 0.2	A: 0.43 (40) B: 0.25 (60) C: 0.22 (70)	70 @ 500 hours
	≥50	900 (202)	810 (182)	350 (79)	-	350 (79)	-				
Oregon Type 2	<50 Woven	1401 (315)	-	489 (110)	2758 (620)	-	-	-	0.5	0.42 (40)	70 @ 500 hours
	≥50 Non-woven	890 (200)	-	356 (80)	1913 (430)	-	-				

Table I-1. Bank Protection/Erosion Control Specifications (continued)

AASHTO/ FHWA/ State DOT	Elongation (%)	Min. Grab Strength [N (lb)]	Min. Sewn Seam Strength [N (lb)]	Min. Tear Strength [N (lb)]	Min. Puncture Strength [N (lb)]	Min. Puncture Strength [N (lb)]	Min. Burst Strength [kPa (psi)]	in situ Soil Passing 0.0775 mm (%)	Min. Permittivity (sec^{-1})	Max. AOS [mm (Sieve No.)]	Min. UV Stability (%)
	ASTM D4632	ASTM D4632	ASTM D4632	ASTM D4533	ASTM D6241	ASTM D4833	ASTM D3786	AASHTO T88	ASTM D4491	ASTM D4751	ASTM D4355
Washington High Classes A,B,C	15-50 Woven	1401 (315)	1201 (270)	498 (112)	2758 (620)	-	-	-	A: 0.7 B: 0.4 C: 0.2	A: 0.42 (40) B: 0.25 (60) C: 0.21 (70)	70 @ 500 hours
	≥50 Non-woven	890 (200)	801 (180)	351 (79)	1913 (430)	-	-				
Arizona	15-115 WMF or Non-woven	889 (200)	-	222 (50)	-	334 (75)	2206 (320)	-	0.5	0.11-0.60 (140-30)	70
AASHTO, Alaska Class 2 (For WMF)	<50	1100 (247)	990 (223)	250 (56)	2200 (495)	-	-	<15 15 to 50 >50	0.7 0.2 0.1	0.43 (40) 0.25 (60) 0.22 (70)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	1375 (209)	-	-				
FHWA Types IV-D, IV-E, IV-F	<50	1100 (247)	990 (223)	400 [(2)] (90)	-	400 (90)	2750 (399)	-	D: 0.7 E: 0.2 F: 0.1	D: 0.43 (40) E: 0.25 (60) F: 0.22 (70)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	-	250 (56)	1350 (196)				
Montana Moderate Classes A,B,C	<50	1100 (247)	990 (223)	400 (90)	-	400 (90)	-	<15 15 to 50 >50	A: 0.7 B: 0.4 C: 0.2	A: 0.43 (40) B: 0.25 (60) C: 0.22 (70)	70 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	-	250 (56)	-				
Oregon Type 1	<50 Woven	1112 (250)	-	400 (90)	2202 (495)	-	-	-	0.5	0.42 (40)	70 @ 500 hours
	≥50 Non-woven	712 (160)	-	249 (56)	1379 (310)	-	-				

Table I-1. Bank Protection/Erosion Control Specifications (continued)

AASHTO/ FHWA/ State DOT	Elongation (%)	Min. Grab Strength [N (lb)]	Min. Sewn Seam Strength [N (lb)]	Min. Tear Strength [N (lb)]	Min. Puncture Strength [N (lb)]	Min. Puncture Strength [N (lb)]	Min. Burst Strength [kPa (psi)]	in situ Soil Passing 0.0775 mm (%)	Min. Permittivity (sec^{-1})	Max. AOS [mm (Sieve No.)]	Min. UV Stability (%)
	ASTM D4632	ASTM D4632	ASTM D4632	ASTM D4533	ASTM D6241	ASTM D4833	ASTM D3786	AASHTO T88	ASTM D4491	ASTM D4751	ASTM D4355
Washington Moderate Classes A,B,C	15-50 Woven	1112 (250)	979 (220)	356 (80)	2202 (495)	-	-	-	A: 0.7 B: 0.4 C: 0.2	A: 0.42 (40) B: 0.25 (60) C: 0.21 (70)	70 @ 500 hours
	≥50 Non-woven	712 (160)	623 (140)	222 (50)	1379 (310)	-	-				
Idaho Type I Low/ Moderate	≥15	578 (130)	-	178 (40)	1779 (400)	-	-	-	0.5	0.30 (50)	70 @ 150 hours

(1) Units: N-Newton; kPa-kilopascal; psi-pounds per square inch; sec-second; mm-millimeter; WMF-woven monofilament

(2) The tear strength for WMF geotextiles is 245 N (55 lb)

APPENDIX J: SUMMARY OF SELECT STATE AND FEDERAL TEMPORARY SILT FENCE SPECIFICATIONS

Table J.1 Temporary Silt Fence Specifications [1]

Specification	Supported or Unsupported -	Elongation (%) ASTM D4632	Minimum Grab Strength Machine Direction [N (lb)] ASTM D4632	Minimum Grab Strength Cross Machine Direction [N (lb)] ASTM D4632	Maximum Post Spacing [m(ft)] -	Minimum Permittivity (sec^{-1}) ASTM D4491	Maximum AOS [mm (Sieve No.)] ASTM D4751	Minimum UV Stability (%) ASTM D4355
AASHTO, Alaska	Supported	-	400 (90)	400 (90)	1.2 (4.0)	0.05	0.60 (30)	70 @ 500 hours
	Unsupported	<50	550 (124)	450 (101)	2.0 (6.5)			
		≥50	550 (124)	450 (101)	1.2 (4.0)			
FHWA Type V-A	-	-	400 (90)	400 (90)	-	0.05	0.60 (30)	70 @ 500 hours
FHWA Type V-B	-	<50	550 (124)	450 (101)	-			
FHWA Type V-C	-	≥50	550 (124)	450 (101)	-			
California Woven	-	≥15	534 (120)	534 (120)	-	0.1	0.58 (30)	70 @ 500 hours
California Nonwoven	-	≥50	534 (120)	534 (120)	-	1.1	0.58 (30)	70 @ 500 hours
Idaho	Supported or Unsupported	<50 (not applicable for supported)	400 (90)	400 (90)	-	0.05	0.84 (20)	70 @ 150 hours
Montana	Supported	-	400 (90)	400 (90)	-	0.05	0.60 (30)	70 @ 500 hours
	Unsupported	-	550 (124)	450 (101)				
Oregon	Supported	-	400 (90)	400 (90)	-	0.05	0.60 (30)	70 @ 500 hours
	Unsupported	<50	534 (120)	445 (100)	-			
		≥50	534 (120)	445 (100)	-			
Washington	Supported	-	445 (100)	445 (100)	-	0.02	Woven Slit Film = 0.60 (30) Other Types = 0.30 (50) Minimum = 0.15 (100)	70 @ 500 hours
	Unsupported	≤30 [at ≥ 801 N (180lb)]	801(180)	445 (100)	-			
Arizona	Supported or Unsupported	≤50 [at 267 N (60 lb)]	445 (100)	445 (100)	1.8 (6.0)	0.05	0.60 (30)	70

(1) Units: N-Newton; lb-pound; m-meter; ft-foot; sec-second; mm-millimeter

APPENDIX K: SUMMARY OF SELECT STATE AND FEDERAL DRAINAGE FABRIC SPECIFICATIONS

Table K-1. Drainage Fabric Specifications [1]

AASHTO/ FHWA/ State DOT	Elongation (%) ASTM D4632	Minimum Grab Strength [N (lb)] ASTM D4632	Minimum Sewn Seam Strength [N (lb)] ASTM D4632	Minimum Tear Strength [N (lb)] ASTM D4533	Minimum Puncture Strength [N (lb)] ASTM D6241	Minimum Puncture Strength [N (lb)] ASTM D4833	Minimum Burst Strength [kPa (psi)] ASTM D3786	in situ Soil Passing 0.0775 mm (%) AASHTO T88	Minimum Permittivity (sec^{-1}) ASTM D4491	Maximum AOS [mm (Sieve No.)] ASTM D4751	Minimum UV Stability (%) ASTM D4355
Montana High Classes A,B,C	<50	1400 (315)	1260 (283)	500 (112)	-	500 (112)	-	<15 15 to 50 >50	A: 0.5 B: 0.4 C: 0.3	A: 0.43 (40) B: 0.25 (60) C: 0.18 (80)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (79)	-	350 (79)	-				
AASHTO, Alaska Class 2	<50	1100 (247)	990 (223)	400[A] (90)	2200 (495)	-	-	<15 15 to 50 >50	0.5 0.2 0.1	0.43 (40) 0.25 (60) 0.22 (70)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	1375 (309)	-	-				
FHWA Types I-A,I-B,I-C	<50	1100 (247)	990 (223)	400[B] (90)	-	400 (90)	2750 (400)	-	A: 0.5 B: 0.2 C: 0.1	A: 0.43 (40) B: 0.25 (60) C: 0.22 (70)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	-	250 (56)	1344 (195)				
California Classes A,B,C	≥50	700 (157)	-	249 (56)	1379 (310)	-	-	-	A: 0.5 B: 0.2 C: 0.1	A: 0.42 (40) B: 0.25 (60) C: 0.21 (70)	70 @ 500 hours
Montana Moderate Classes A,B,C	<50	1100 (247)	990 (223)	400 (90)	-	400 (90)	-	<15 15 to 50 >50	A: 0.5 B: 0.4 C: 0.3	A: 0.43 (40) B: 0.25 (60) C: 0.18 (80)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	-	250 (56)	-				
Oregon Type 2	<50 Woven	1112 (250)	-	400 (90)	2202 (495)	-	-	-	0.5	0.42 (40)	50 @ 500 hours
	≥50 Nonwoven	712 (160)	-	249 (56)	1379 (310)	-	-				
Washington Moderate Classes A,B,C	<50 Woven	1112 (250)	979 (220)	400 (90)	2202 (495)	-	-	- -	A: 0.5 B: 0.4 C: 0.3	A: 0.42 (40) B: 0.25 (60) C: 0.18 (80)	50 @ 500 hours
	≥50 Nonwoven	712 (160)	623 (140)	249 (56)	1379 (310)	-	-				

Table K-1. Drainage Fabric Specifications (continued)

AASHTO/ FHWA/ State DOT	Elongation (%) ASTM D4632	Minimum Grab Strength [N (lb)] ASTM D4632	Minimum Sewn Seam Strength [N (lb)] ASTM D4632	Minimum Tear Strength [N (lb)] ASTM D4533	Minimum Puncture Strength [N (lb)] ASTM D6241	Minimum Puncture Strength [N (lb)] ASTM D4833	Minimum Burst Strength [kPa (psi)] ASTM D3786	in situ Soil Passing 0.0775 mm (%) AASHTO T88	Minimum Permittivity (sec^{-1}) ASTM D4491	Maximum AOS [mm (Sieve No.)] ASTM D4751	Minimum UV Stability (%) ASTM D4355
AASHTO, Alaska Class 3	<50	800 (180)	720 (162)	300 (67)	1650 (371)	-	-	<15 15 to 50 >50	0.5 0.2 0.1	0.43 (40) 0.25 (60) 0.22 (70)	50 @ 500 hours
	≥50	500 (112)	450 (101)	180 (40)	990 (223)	-	-				
FHWA Types I-D,I-E,I-F	<50	800 (180)	720 (162)	300 (67)	-	300 (67)	2100 (305)	-	D: 0.5 E: 0.2 F: 0.1	D: 0.43 (40) E: 0.25 (60) F: 0.22 (70)	50 @ 500 hours
	≥50	500 (112)	450 (101)	175 (39)	-	175 (39)	950 (137)				
Oregon Type 1	<50 Woven	801 (180)	-	298 (67)	1646 (370)	-	-	-	0.5	0.42 (40)	50 @ 500 hours
	≥50 Nonwoven	512 (115)	-	178 (40)	979 (220)	-	-				
Washington Low Classes A,B,C	<50 Woven	801 (180)	712 (160)	298 (67)	1646 (370)	-	-	-	A: 0.5 B: 0.4 C: 0.3	A: 0.42 (40) B: 0.25 (60) C: 0.18 (80)	50 @ 500 hours
	≥50 Nonwoven	512 (115)	445 (100)	178 (40)	979 (220)	-	-				
Idaho Type II	-	801 (180)	-	-	2224 (500)	-	-	-	0.7	-	-
Arizona	45-115	622 (140)	-	178 (40)	-	222 (50)	1448 (210)	-	0.5	0.11 to 0.60 (140-30)	70
Idaho Type I	-	356 (80)	-	-	1334 (300)	-	-	-	0.7	0.21 (70)	-

(1) Units: N-Newton; lb-pound; kPa-kilopascal; psi-pounds per square inch; sec-second; ft-foot; mm-millimeter

APPENDIX L: SUMMARY OF SELECT STATE AND FEDERAL STABILIZATION FABRIC SPECIFICATIONS

Table L-1. Stabilization Fabric Specifications [1]

Specification	Elongation (%) ASTM D4632	Minimum Grab Strength [N (lb)] ASTM D4632	Minimum Sewn Seam Strength [N (lb)] ASTM D4632	Minimum Tear Strength [N (lb)] ASTM D4533	Minimum Puncture Strength [N (lb)] ASTM D6241	Minimum Puncture Strength [N (lb)] ASTM D4833	Minimum Burst Strength [kPa (psi)] ASTM D3786	in situ Soil Passing 0.0775 mm (%) AASHTO T88	Minimum Permittivity (sec^{-1}) ASTM D4491	Maximum AOS [mm (Sieve No.)] ASTM D4751	Minimum UV Stability (%) ASTM D4355
AASHTO Class 1	<50	1400 (315)	1260 (283)	500 (112)	2750 (618)	-	-	-	0.05	0.43 (40)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (79)	1925 (433)	-	-	-			
FHWA Type III-A	<50	1400 (315)	1260 (283)	500 (112)	-	1400 (315)	508 (3500 kPa)	-	0.05	0.43 (40)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (79)	-	900 (202)	247 (1300 kPa)	-			
Alaska Class 1	<50	1400 (315)	1260 (283)	500 (112)	2750 (618)	-	-	-	0.08	0.43 (40)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (79)	1925 (433)	-	-	-			
California Class B1	<50	-	-	-	2758 (620)	-	-	-	0.2	0.60 (30)	70 @ 500 hours
California Class B2	<50	1423 (320)	-	534 (120)	2758 (620)	-	-	-	0.2	0.30 (50)	70 @ 500 hours
California Class B3	≥50	890 (200)	-	356 (80)	1913 (430)	-	-	-			
Montana	<50	1400 (315)	1260 (283)	500 (112)	-	1400 (315)	-	-	0.10	0.43 (40)	50 @ 500 hours
	≥50	900 (202)	810 (182)	350 (79)	-	900 (202)	-				
Washington	<50 Woven	1401 (315)	1201 (270)	498 (112)	2758 (620)	-	-	-	0.10	0.42 (40)	50 @ 500 hours
	≥50 Nonwoven	890 (200)	801 (180)	351 (79)	1913 (430)	-	-	-			

Table L-1. Stabilization Fabric Specifications (continued)

Specification	Elongation (%) ASTM D4632	Minimum Grab Strength [N (lb)] ASTM D4632	Minimum Sewn Seam Strength [N (lb)] ASTM D4632	Minimum Tear Strength [N (lb)] ASTM D4533	Minimum Puncture Strength [N (lb)] ASTM D6241	Minimum Puncture Strength [N (lb)] ASTM D4833	Minimum Burst Strength [kPa (psi)] ASTM D3786	in situ Soil Passing 0.0775 mm (%) AASHTO T88	Minimum Permittivity (sec^{-1}) ASTM D4491	Maximum AOS [mm (Sieve No.)] ASTM D4751	Minimum UV Stability (%) ASTM D4355
FHWA Type III-B	<50	1100 (247)	990 (223)	400 (2) (90)	-	400 (90)	2700 (392)	-	0.05	0.43 (40)	50 @ 500 hours
	≥50	700 (157)	630 (142)	250 (56)	-	250 (56)	1300 (189)	-			
California Class A1	<50	1112 (250)	-	400 (90)	2224 (500)	-	-	-	0.05	0.30 (50)	70 @ 500 hours
California Class A2	≥50	712 (160)	-	267 (60)	1379 (310)	-	-	-			

(1) Units: N-Newton; lb-pound; kPa-kilopascal; psi-pounds per square inch; sec-second; mm-millimeter

(2) The tear strength for woven monofilament (WMF) geotextiles is 245 N (55 lb).

APPENDIX M: SUMMARY OF SELECT STATE GEOCOMPOSITE WALL DRAIN/EDGE DRAIN SPECIFICATIONS

Table M.1 Geocomposite Wall Drain/Edge Drain Specifications – Core [1]

	Wall					Edge					
State	Minimum Thickness with Fabric [mm(inch)] ASTM D1777	Minimum Compressive Strength [kPa(psf)] ASTM D1621	Gradient ASTM D4716	Normal Stress [kPa(psf)] ASTM D4716	Geocomposite Minimum Transmissivity [l/min/m (gal/min/ft)] ASTM D4716	Minimum Thickness with Fabric [mm(inch)] ASTM D1777	Minimum Compressive Strength [kPa(psf)] ASTM D1621	Gradient ASTM D4716	Normal Stress [kPa(psf)] ASTM D4716	Geocomposite Minimum Transmissivity [l/min/m (gal/min/ft)] ASTM D4716	Minimum Width [m(ft)] Measured
California	-	-	1.0	239 (5,000)	50 (4)	-	-	-	-	-	-
Kansas	-	479 (10,000)	1.0	239 (5,000)	124 (10)	-	-	-	-	-	-
Missouri	9.7 (0.38)	278 (6,000)	-	-	62 (5)	25 (1)	335 (7,000)	≤ 0.1	69 (1,440)	186 (15)	0.3 (1)
Ohio	-	-	-	-	-	25 (1)	278 (6,000)	0.1	69 (1,440)	124 (10)	-
Virginia	-	276 (5,760)	≤ 0.1	69 (1,440)	186 (15)	19 (0.75)	276 (5,760)	≤ 0.1	69 (1,440)	186 (15)	0.3 (1)
West Virginia	-	-	-	-	-	19 (0.75)	144 (3,000)	0.1	69 (1,440)	124 (10)	-
Arizona	5.8 (0.23)	278 (6,000)	1.0	144 (3,000)	50 (4)	19 (0.75)	192 (4,000)	0.1	72 (1,500)	50 (4)	0.3 (1)

(1) Units: mm-millimeter; kPa-kiloPascal; psf-pounds per square foot; gal-gallons; min-minute; ft-foot

Table M-2. Geocomposite Wall Drain/Edge Drain Specifications – Fabric [1]

Specification	Minimum Weight [g/m^2 (oz/yd^2)] ASTM D3776	Elongation (%) ASTM D4632	Minimum Grab Strength [N (lb)] ASTM D4632	Minimum Tear Strength [N (lb)] ASTM D4533	Minimum Puncture Strength [N (lb)] ASTM D6241	Minimum Puncture Strength [N (lb)] ASTM D4833	Minimum Burst Strength [kPa (psi)] ASTM D3786	in situ Soil Passing 0.0775 mm (%) AASHTO T88	Minimum Permittivity (sec^{-1}) ASTM D4491	Maximum Apparent Opening Size [mm (Sieve)] ASTM D4751	Minimum UV Stability (%) ASTM D4355
California Classes A,B,C (Wall Only)	-	≥50	700 (157)	-	-	-	1448 (210)	-	A: 0.5 B: 0.2 C: 0.1	A: 0.42 (40) B: 0.25 (60) C: 0.21 (70)	70 @ 500 hours
Kansas (Wall Only)	-	≥50	700 (157)	250 (56)	1375 (309)	-	-	>50	0.1	0.22 (70)	50 @ 500 hours
Missouri (Wall,Edge)	-	<50	1100 (247)	400[2] (90)	2200 (495)	-	-	<15 15 to 50 >50	1.0	0.43 (40) 0.25 (60) 0.22 (70)	70 @ 500 hours
		≥50	700 (157)	250 (56)	1375 (309)	-	-				
Ohio (Edge Only)	-	-	355 (80)	110 (25)	625 (1441)	110 (25)	-	≤50 50-85	0.5	0.60 (30) 0.30 (50)	-
Virginia (Wall, Edge)	-	<50	800 (180)	-	-	-	-	-	0.5	0.30 (50)	-
		≥50	500 (112)	-	-	-	-	-			
West Virginia (Edge Only)	-	<50	400 (90)	400[a] (90)	2200 (495)	-	-	-	0.2	0.25 (60)	70 @ 500 hours
		≥50	400 (90)	250 (56)	1375 (309)	-	-	-			
Arizona (Wall, Edge)	119 (3.5)	Nonwoven 35-115	400 (90)	134 (30)	-	134 (30)	965 (140)	-	0.5	0.11-0.60 (30-140)	70

(1) Units: g-gram; oz-ounce; yd-yard; N-Newton; lb-pound; psi-pounds per square inch; sec-second

(2) For woven monofilament geotextiles, the tear strength is 250 N (56 lb)

APPENDIX N: COMPARISON OF ADOT GEOGRID SPECIFICATIONS WITH GEOGRID SPECIFICATIONS OF 10 OTHER STATES

Table N-1. Alaska DOT&PF [(1)] Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	Alaska DOT&PF Table 729-1
Average Aperture Size (In) MD (machine direction) XD (cross machine direction)	I.D. Calipered	 0.8-2.0 0.8-2.0	 0.8-2.0 0.8-2.0
Open Area (%)	USACE Method	70 min.	Not specified
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	 40 min.
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	N/A
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	 400 min. 800 min.
Tensile modulus (lb/ft) MD XD	ASTM 6637	Not specified	Not specified
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	Not specified
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG-GG2	N/A	90 % min.
Junction Strength (lb/ft)	ASTM D7737	N/A	N/A
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	Not specified
Installation Damage Resistance (%)	ASTM D6637	Not specified	80 min.
UV Resistance, % retained tensile strength, 500 hours	ASTM D 4355	Not specified	Not specified
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified

(1) Alaska Department of Transportation and Public Facilities (Alaska DOT&PF)

Table N-2. California DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	California DOT 88-1.02P Biaxial
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	 0.8-1.3 1.0-1.6
Open Area (%)	USACE Method	70 min.	Not specified
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	 40 min. 150 min.
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	N/A
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	 410 (MD) x 620 (XD) 1310 (MD) x 1970 (XD)
Tensile modulus (lb/ft) MD XD	ASTM 6637	Not specified	Not specified
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	N/A
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	750,000 min.
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG-GG2	N/A	N/A
Junction Strength (lb/ft)	ASTM D7737	N/A	1220 (MD)x 1830 (XD)
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	0.65 min.
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified
UV Resistance, % retained tensile strength, 500 hours	ASTM D 4355	Not specified	100 min.
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified

Table N-3. Indiana DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	Indiana DOT 918.05 Geogrid Type IA	Indiana DOT 918.05 Geogrid Type IB
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	 1.3 min. 1.3 min.	 1.3 min. 1.3 min.
Open Area (%)	USACE Method	70 min.	50-80	50-80
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	 Not specified	 Not specified
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	N/A	N/A
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	 800 min.	 800 min.
Tensile modulus (lb/ft) MD XD	ASTM 6637	Not specified	 10,000 min. 10,000 min.	 10,000 min. 10,000 min.
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	Not specified	Not specified
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	Not specified	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG-GG2	N/A	N/A	N/A
Junction Strength (lb/ft)	ASTM D7737	N/A	Not specified	788 min.
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	Not specified	Not specified
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified	Not specified
UV Resistance, % retained tensile strength, 500 hours	ASTM D 4355	Not specified	Not specified	70 min.
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified	Not specified

Table N-4. Kansas DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	Kansas DOT Table 1710-1 Base Course	Kansas DOT Table 1710-2 Subgrade
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	Not specified due to fabric or geogrid	Not specified due to fabric or geogrid
Open Area (%)	USACE Method	70 min.	Not specified	Not specified
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	Not specified due to fabric or geogrid	Not specified due to fabric or geogrid
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	 280 MD, 450 CD (cross machine direction) 580 MD, 900 CD Not specified	 410 MD, 620 CD 810 MD, 1,340 CD Not specified
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	N/A	N/A
Tensile modulus (lb/ft) MD XD	ASTM 6637	Not specified	Not specified	Not specified
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	Not specified	Not specified
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	Not specified	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG2	N/A	25 lb min.	25 lb min.
Junction Strength (lb/ft)	ASTM D7737	N/A	N/A	N/A
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	0.32 min.	Not specified
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified	Not specified
UV Resistance, % retained tensile strength, 500 hours	ASTM D 4355	Not specified	Not specified	Not specified
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified	0.8

Table N-5. Kentucky DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	Kentucky DOT Type 1	Kentucky DOT Type 2
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	 1.0 min. 1.375 min.	 1.0 min. 1.375 min.
Open Area (%)	USACE Method	70 min.	Not specified	Not specified
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	 Not specified	 Not specified
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	 280 MD, 450 XD 580 MD, 920 XD Not specified	 410 MD, 600 XD 810 MD, 1,340 XD Not specified
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	 800 min.	 800 min.
Tensile modulus (lb/ft) MD XD	ASTM 6637	Not specified	 15,170 min. 24,685 min.	 32,980 min. 44,725 min.
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	Not specified	Not specified
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	Not specified	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG2	N/A	MD 765 lb/ft XD 1,170 lb/ft	MD 1,080 lb/ft XD 1,780 lb/ft
Junction Strength (lb/ft)	ASTM D7737	N/A	Not specified	788 min.
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	Not specified	Not specified
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified	Not specified
UV Resistance, % retained tensile strength, 500 hours	ASTM D 4355	Not specified	Not specified	Not specified
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified	Not specified

Table N-6. Maine DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	Maine DOT Section 620
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	 0.75-3.0 0.75-3.0
Open Area (%)	USACE Method	70 min.	50-80
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	Not specified
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	N/A
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	 600 min. 1,200 min Not specified
Tensile modulus (lb/ft) MD XD	ASTM 6637	N/A	Not specified
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	Not specified
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG2	N/A	N/A
Junction Strength (lb/ft)	ASTM D7737	N/A	1,000 min.
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	Not specified
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified
UV Resistance, % retained tensile strength, 500 hours	ASTM D 4355	Not specified	Not specified
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified

Table N-7. New Mexico DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	New Mexico DOT 2012 Type 1 Biaxial	New Mexico DOT 2012 Type 2 Biaxial	New Mexico DOT 2012 Type 1 Triax	New Mexico DOT 2012 Type 2 Triax
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	 1.0-1.3 1.0-1.3	 1.0-1.3 1.0-1.3	 1.3 min. In any direction	 1.6 min. In any direction
Open Area (%)	USACE Method	70 min.	Not specified	Not specified	Not specified	Not specified
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified	Not specified	Not specified	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	Not specified	Not specified	Not specified.	Not specified
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	N/A	N/A	N/A	N/A
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	 280 MD, 450 XD Not specified 850 MD, 1,300 XD	 410 MD, 620 XD Not specified 1,310 MD, 1,970 XD	N/A	N/A
Radial Stiffness at 0.5% (lb/ft) Isotropic Stiffness Ratio	ASTM 6637	N/A	N/A	N/A	13,700 min. 0.60	15,400 min. 0.60
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	N/A	N/A	Not specified	Not specified
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	250,000 min.	750,000 min.	Not specified	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A	N/A	N/A	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG2	N/A	N/A	N/A	N/A	N/A
Junction Efficiency (%)	ASTM D7737	N/A	93 min.	93 min.	93 min.	93 min.
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	0.32	0.65	Not specified	Not specified
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified	Not specified	Not specified	Not specified
Resistance to long-term degradation (%)	EPA 9030 and ASTM D4355	Not specified	100 min. 70 min.	100 min. 70 min.	100 min. 70 min.	100 min. 70 min.
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified	Not specified	Not specified	Not specified

Table N-8. Ohio DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	Ohio DOT 861 Subgrade Stabilization
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	 0.75-3.0 0.75-3.0
Open Area (%)	USACE Method	70 min.	Not specified
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	Not specified
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	N/A
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	 400 min. Not specified 1,300 min.
Tensile modulus (lb/ft) MD XD	ASTM 6637	N/A	Not specified
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	Not specified
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG2	N/A	130 lb min.
Junction Strength (lb/ft)	ASTM D7737	N/A	N/A
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	Not specified
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified
UV Resistance, % retained tensile strength, 500 hours	ASTM D 4355	Not specified	70 min.
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified

Table N-9. Oklahoma DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	Oklahoma DOT Type 1	Oklahoma DOT Type 2
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	 1.0-2.0 1.0-2.0	 1.0-2.0 1.0-2.0
Open Area (%)	USACE Method	70 min.	70 min	70 min.
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	 Not specified	 Not specified
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	N/A	N/A
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	 Not specified Not specified 850 min.	 Not specified Not specified 1,300 min.
Tensile modulus (lb/ft) MD XD	ASTM 6637	N/A	 14,000 min. 14,000 min.	 20,000 min. 20,000 min.
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	250,000 min.	750,000 min.
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	Not specified	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	N/A	N/A
Junction Strength (%), (lb) (lb/ft)	GRI GG2	N/A	50 lb min.	75 lb min.
Junction Strength (lb/ft)	ASTM D7737	N/A	N/A	N/A
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	2.56 min.	3.7 min.
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified	Not specified
UV Resistance, % retained tensile strength, 500 hours	ASTM D 4355	Not specified	Not specified	Not specified
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified	Not specified

Table N-10. Utah DOT Geogrid Specifications

Property	Test Method	ADOT 1014-3 Geogrid	Utah DOT Type 1 Subgrade Stab.	Utah DOT Type 2 Subgrade Stab.	Utah DOT Type 1 Base Reduction	Utah DOT Type 2 Base Reduction
Average Aperture Size (In) MD XD	I.D. Calipered	 0.8-2.0 0.8-2.0	 1.0-1.5 1.0-1.5	 1.0-1.5 1.0-1.5	 1.0-1.5 1.0-1.5	 1.0-1.5 1.0-1.5
Open Area (%)	USACE Method	70 min.	Not specified	Not specified	Not specified	Not specified
Weight (oz/yd)	ASTM D3776	5.5 min.	Not specified	Not specified	Not specified	Not specified
Thickness (mils) At Rib At Junction	ASTM D1777 or Calipered	 30 min. 60 min.	 30 min.	 50 min.	 30 min.	 50 min.
Wide-Width Strip Tensile Strength (lb/ft) At 2% Strain At 5% Strain At 15% Strain or ultimate	ASTM D4595	 275 min. 550 min. 800 min.	Not specified	Not specified	N/A	N/A
Tensile Strength (lb/ft) At 2% Strain At 5% Strain At ultimate	ASTM D6637	N/A	Not specified	Not specified	 280 MD, 450 XD 580 MD, 920 XD Not specified.	 410 MD, 620 XD 810 MD, 1,340 XD Not specified
Tensile modulus (lb/ft) MD XD	ASTM 6637	N/A	 17.140 min. 27,240 min.	 27,240 min. 44,150 min.	Not specified.	Not specified
Flexural Rigidity (mg-cm)	ASTM D1388	250,000 min.	Not specified	Not specified	Not specified	Not specified
Overall flexural rigidity (mg-cm)	ASTM D7748	N/A	Not specified	Not specified	Not specified	Not specified
Junction Strength (%)	ASTM D638 Modified	80 min.	Not specified	Not specified	Not specified	Not specified
Junction Strength (%), (lb) (lb/ft)	GRI GG2	N/A	Not specified	Not specified	50 lb min.	Not specified
Junction Strength (lb/ft)	ASTM D7737	N/A	Not specified	Not specified	N/A	Not specified
Torsional Rigidity at 20 cm-kg (mm-kg/degree)	GRI:GG9	Not specified	Not specified	Not specified	Not specified	Not specified
Installation Damage Resistance (%)	ASTM D6637	Not specified	Not specified	Not specified	Not specified	Not specified
Resistance to long-term degradation (%)	EPA 9030 and ASTM D4355	Not specified	95 min.	95 min.	100 min.	100 min.
Coefficient of Soil Interaction	GRI-GT6/GG5	Not specified	Not specified	Not specified	Not specified	Not specified

APPENDIX O: ADOT FLEXIBLE PAVEMENT DESIGN METHOD—EQUATIONS AND METHODOLOGY

The basic AASHTO design equation for flexible pavements is shown below:

(Eq. O-1)

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Where:

W_{18}	=	the predicted number of 18-kip equivalent single axle load (ESAL) applications
Z_R	=	the standard normal deviate
S_o	=	the combined standard error of the traffic prediction and the performance prediction
ΔPSI	=	$P_0 - P_t$
P_0	=	the initial design serviceability index
P_t	=	the terminal serviceability index
M_R	=	the resilient modulus (psi)
SN	=	the structural number of the total pavement section required.

All variables except for SN are identified for the design. The equation can be solved or a nomograph is used to find SN based on the other variables. The values for the other variables in the equation are identified as follows.

W_{18}

According to the MPEDM, the number of ESALs for a design period is determined by the Pavement Management Branch of the Materials Section for ADOT. The factors considered in the determination of the design load include:

- Traffic volume, Average Daily Traffic (ADT) plus growth factor.
- Vehicle equivalencies (growth factor and tire pressure).
- Vehicle classification.

Z_R

The standard normal deviate is an estimate of how likely a pavement is to fail within the selected design period. The standard normal deviate is obtained from Table 202.02-1 in the MPEDM. The standard normal deviate is based on the type of roadway, expected traffic volume, and the desired level of reliability expressed as a percent.

S_o

The standard error value is identified in the MPEDM as 0.45, as was reportedly obtained from the AASHTO Guide. ADOT reports that they currently use 0.35.

ΔPSI

The change in serviceability index is obtained from Table 202.02-2 in the MPEDM. The change in serviceability index is based on the type of roadway and the expected traffic volume.

M_R

The Resilient Modulus (M_R) is an expression of soil strength and is determined through R-Value analysis of soil samples from the subgrade. Both correlated R-Values (R_c) and actual R-Values (R_a) are used to determine a mean R-Value for design. The correlated R-Value is based on the percent passing the No. 200 Sieve and the Plasticity Index (PI) of soil samples and is obtained from Table 202.02-3 in the MPEDM. The actual R-Value is obtained by performing R-value tests on soil samples. The mean R-Value (R_{mean}) is calculated using the following equation:

$$R_{mean} = \frac{N_t R_t \sigma_c^2 + N_c R_c \sigma_t^2}{N_t \sigma_c^2 + N_c \sigma_t^2} \quad \text{(Eq. O-2)}$$

Where:

- N_t = Number of actual R-Values
- N_C = Number of correlated R-Values
- R_t = Mean of actual R-Values
- R_c = Mean of correlated R-Values
- σ_t = Standard deviation of actual R-Values
- σ_c = Standard deviation of correlated R-Values

The R-Value is converted to the Resilient Modulus using the following equation:

$$M_R = \frac{1815 + 225 * (R_{mean}) + 2.40 * (R_{mean})^2}{0.6(SVF)^{0.6}} \quad \text{(Eq. O-3)}$$

Where:

- R_{mean} = Mean R-Value
- SVF = Seasonal Variation Factor

The seasonal variation factor is obtained from Figure 202.02-1 or Table 202.02-4 in the MPEDM. The Resilient Modulus is used as the input in the AASHTO equation. Figure 202.02-2 in the MPEDM shows a graphical representation of the M_R, the SVF, and the R-value. The MPEDM also suggests a maximum M_R for subgrade materials of 26,000 psi.

SN

The Structural Number obtained from the pavement design equation is the design parameter that is used to determine the thicknesses of the different layers of the pavement section. The SN is a function of the layer strength coefficients, layer thicknesses, and layer drainage coefficients. The SN can be calculated using the following equation:

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3 \quad \text{(Eq. O-4)}$$

Where:

a_1 = The layer coefficient for the surface course (asphalt)
D_1 = The thickness of the surface course (asphalt)
a_2 = The layer coefficient for the base course (ABC)
D_2 = The thickness of the base course (ABC)
m_2 = The drainage coefficient for the base course (ABC)
a_3 = The layer coefficient for the subbase course
D_3 = The thickness of the subbase
m_3 = The drainage coefficient for the subbase

The equation is solved iteratively, with the layer thicknesses adjusted until the design SN can be met and requirements for any minimum or maximum layer thicknesses are also satisfied. The layer coefficients are obtained from Table 202.02-6 in the MPEDM. The drainage coefficients are obtained from Table 202.02-7 in the MPEDM.

APPENDIX P: CBR AND R-VALUE TO MODULUS CORRELATION

Soil Properties Used in Design Guidelines

The design guidelines that were reviewed used different soil strength properties to determine whether base/subbase reinforcement was appropriate. These properties included: California Bearing Ratio (CBR), Subgrade Modulus (M_r), and soil Resistance Value (R-Value). M_r is the definitive engineering property used to characterize subgrade soil. However, M_r testing can be costly and time consuming. As a result, CBR and R-Value testing are often used as a substitute to estimate M_r. A M_r value can be calculated from a measured CBR or R-Value by using a correlation equation.

NCHRP 1-37A developed equations relating M_r to CBR and to R-Value. ADOT also has developed an equation relating M_r to R-Value. Caltrans identifies corresponding R-Values for specific M_r values in their design guidelines.

ADOT and Caltrans both use the AASHTO T-190 test method for measuring R-Value. However, ADOT and Caltrans have different correlations for estimating a M_r from the measured R-Value. Caltrans is much more conservative, in that it correlates a lower M_r for a given R-Value than ADOT does. The ADOT equation includes the Seasonal Variation Factor (SVF), which will result in different calculated M_r values depending on the value of the SVF.

Correlation Equations

CBR NCHRP 1-37A	$M_R\,(psi) = 2555(CBR)^{0.64}$	
R-Value NCHRP 1-37A	$M_R\,(psi) = 1155+555R$	
R-Value ADOT	$M_R\,(psi) = 1815+225R+2.40R^2/(0.6(SVF)^{0.6})$	SVF=1
R-Value Caltrans	Based on equivalent values shown in "Subgrade Enhancement Geosynthetic Design and Construction Guide," Updated September 21, 2013.	

The values in Table P-1 are the approximate/rounded values calculated on the basis of the given M_r and the applicable equation. Since Caltrans does not have an equation, only the equivalent values that Caltrans reports in their design guidelines are identified in Table P-1.

Table P-1: Correlation Table - Approximate Values for Given M_R

M_R	CBR (NCHRP 1-37A)	R-Value (NCHRP 1-37A)	R-Value (ADOT) SVF=1	CBR (Caltrans)	R-Value (Caltrans)
3,000	1	3	0	2	10
4,500	2	6	4	3	20
5,000	3	7	5	3.5	25
7,500	5	11	11		
9,500	8	15	15	6.5	40
10,000	8	16	16		
12,500	12	20	21		
15,000	16	25	25		
17,500	20	30	30		
20,000	25	34	34		
22,500	30	38	37		
25,000	35	43	41		

Table P-1 shows that the NCHRP 1-37A and the ADOT (SVF=1) equations for R-Value and M_r give very similar results. The Caltrans correlations for R-Value and M_r are much more conservative, meaning that a given R-Value correlates to a lower M_r than would be calculated using the NCHRP 1-37A or ADOT equations.

Table P-1 also shows that a CBR of 3 correlates to an R-Value of 5-7 using the NCHRP 1-37A and ADOT (SVF=1) equations. For the purpose of the proposed ADOT design guidelines, an R-Value of 6 (average of 5 and 7) is correlated to a CBR of 3.

Table P-1 shows that a CBR of 8 correlates to an R-Value of 16 using the NCHRP 1-37A and ADOT (SVF=1) equations.

Figure P-1 illustrates the correlation between R-Value and M_R. The values in Figure P-1 are based on the NCHRP 1-37A and ADOT formulas for calculating an R-Value from a given M_R and the Caltrans R-Values reported to correlate with specific M_R values.

Figure P-2 illustrates the correlation between CBR and M_R. The values in Figure P-2 are based on the NCHRP 1-37A formula for calculating a CBR from a given M_R value and the Caltrans CBR values reported to correlate with specific M_R values.

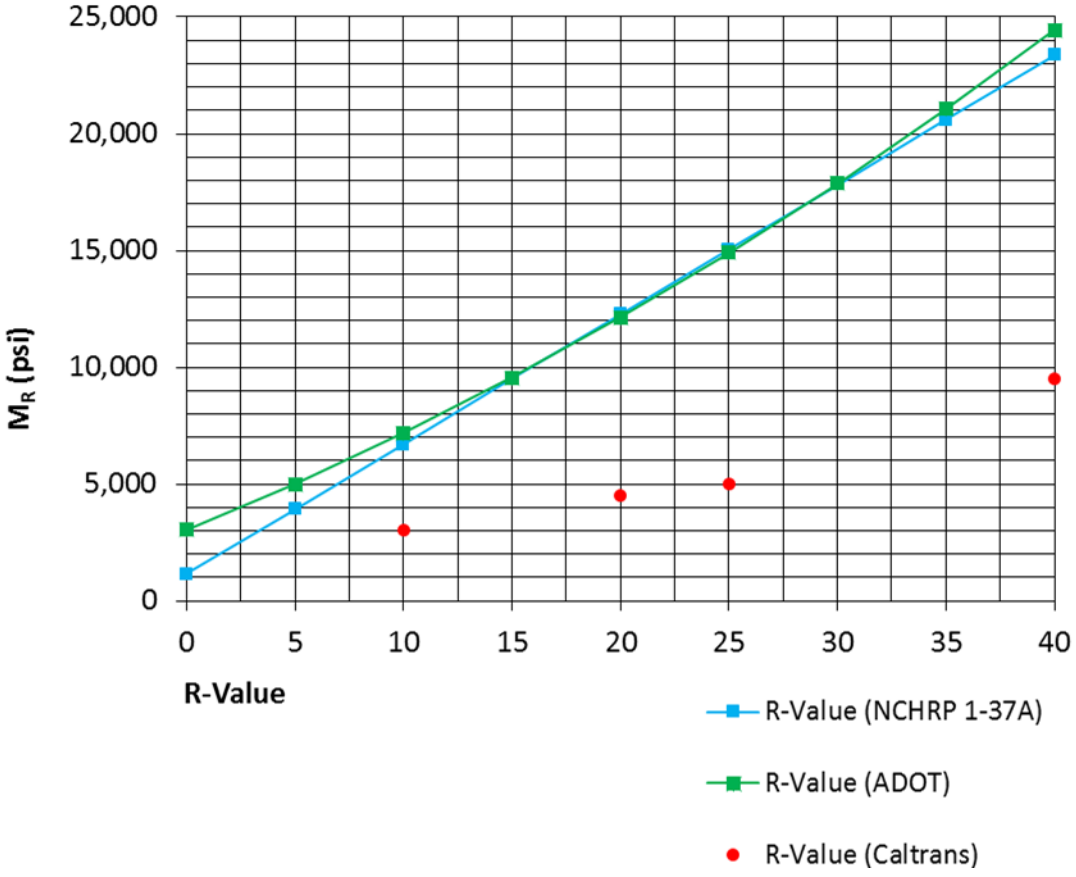

Figure P-1. Correlation of R-Value and M_R

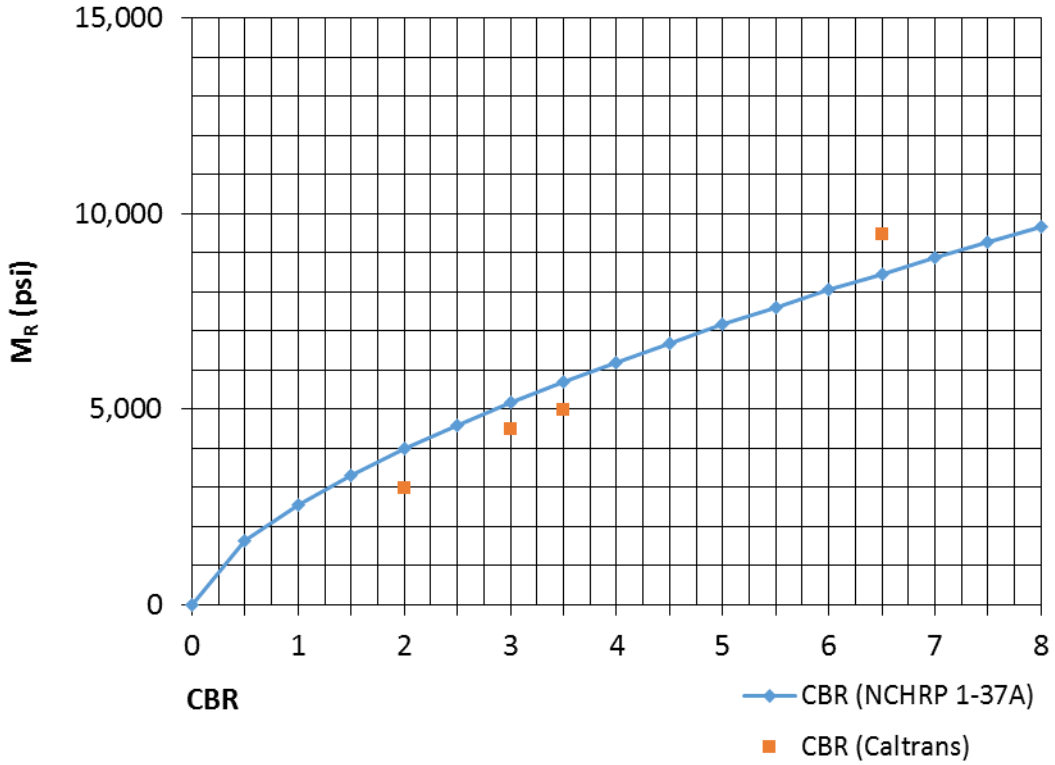

Figure P-2. Correlation of CBR and M_R

APPENDIX Q: RECOMMENDED MODIFICATIONS TO ADOT PRELIMINARY ENGINEERING AND DESIGN MANUAL

Recommended Modifications to ADOT Preliminary Engineering and Design Manual

- On Page 86, G. Mean R-Value Determination, j. should be modified to read:

Feasibility of using Geogrid for base reinforcement with or without geotextile separation fabric. For purposes of design, the mean R-Value should be increased by 10 when geogrid base reinforcement is used, whether or not a geotextile separation fabric is used in conjunction with the geogrid. Refer to Appendix D for Guidelines for the Use of Geogrid for Base Reinforcement and Geotextile Separation Fabric.

- Add the following Appendix D, Guidelines for the Use of Geogrid for Base Reinforcement and Geotextile Separation Fabric:

GUIDELINES FOR THE USE OF GEOGRID FOR BASE REINFORCEMENT AND GEOTEXTILE SEPARATION FABRIC

INTRODUCTION

These guidelines have been developed primarily to aid pavement design engineers in the implementation of geosynthetics, such as geogrids and geotextile fabrics, in the pavement design process for flexible pavements using aggregate base course. The two applications are (1) the use of geogrid for base reinforcement to increase the mean design R-Value in the pavement design process and (2) the use of geotextile fabric to provide a separation between the aggregate base course and the underlying subgrade soil.

The basis of this guide is:

- Over 20 years of successful geogrid and geotextile use on Arizona highways.
- Federal Highway Administration (FHWA) guidance.
- Association of State Highway Transportation Officials (AASHTO) published design practices.
- California Department of Transportation Guidelines for Project Selection and Design - Aggregate Base Enhancement with Biaxial Geogrids for Flexible Pavements, October 20, 2012.

GEOGRID BASE REINFORCEMENT

Geogrid base reinforcement is accomplished by placing a layer of geogrid at the bottom of the aggregate base course or within the aggregate base course.

The use of geogrid below and/or within the base course has the following potential benefits:

- Reduced structural number for the pavement section, which may provide immediate cost savings.
- Increased performance life and reliability of the pavement structure.
- Improved compaction and uniformity over soft or variable soils.
- Reduced hauling and heavy construction truck traffic on local roads due to relatively less material required for removal or replacement or backfill.
- Ability to install the product in a wide range of weather conditions.
- Improved safety due to reduced construction time from reduced hauling and processing of subgrade or backfill materials.

Appropriate Applications of Geogrid Base Reinforcement

Geogrids are intended for use as base reinforcement for asphalt (flexible) pavements only. At this time, the design procedure provides no known benefit for using geogrids for base reinforcement under concrete (rigid) pavements.

Geogrids for base reinforcement have been typically used by ADOT when the mean R-Value for design is greater than or equal to 10 and less than 20. The use of geogrids over subgrade soils with R-Values ranging from 6 to 20 results in a more significant contribution to pavement section reduction than their use over subgrades with R-Values greater than 20.

Limitations of Geogrid Base Reinforcement

Geogrids for base reinforcement are generally not suitable for use when the subgrade has an R-Value greater than 20. The structural enhancement contribution from the geogrid would be relatively small.

Geogrids for base reinforcement should not be utilized over subgrade stabilized with lime or cement. The stabilized subgrade will be relatively stiffer, and the structural enhancement contribution for the geogrid would be relatively small.

Geogrids for base reinforcement are generally not recommended for use over non-stabilized subgrade soils with a mean design R-Value of less than 6. In those cases, removal and replacement, stabilization with lime or cement, or geosynthetic stabilization of the subgrade is recommended.

DESIGN PROCESS FOR GEOGRID BASE REINFORCEMENT

The evaluation of the suitability of geogrid for base reinforcement in the flexible pavement design should be performed in the following manner:

1. Perform a Standard ADOT Flexible Pavement Design

It is assumed that subgrade sampling for pavement design has been performed and a design mean R-Value for design has been determined. The standard pavement design will provide recommended thicknesses for AC and ABC.

2. Perform an ADOT Flexible Pavement Design with Geogrid

Increase the mean design R-Value for the subgrade soil by 10 and determine the required structural number for the pavement section reinforced with geogrid. Determine the required AC and ABC thicknesses for the pavement design with geogrid.

3. Evaluate the Subgrade to Determine Need for a Separation Geotextile Fabric

A subgrade separation fabric may be required along with the geogrid base reinforcement, depending upon the gradation of the subgrade. To ensure performance, use separation geotextile fabric if the gradation of the subgrade is not available or cannot be practically obtained.

Fine materials from the subgrade can migrate upward into the aggregate base, leaving voids in the subgrade or contaminating the ABC and possibly resulting in settlement or subsequent pavement rutting. To control this, a separation geotextile fabric should be placed at the subgrade-aggregate base course interface (below the geogrid base reinforcement). To determine whether a separation geotextile is necessary, the gradation should be evaluated as shown in Table D-1.

Table D-1: Warrant for Separation Geotextile

Subgrade Gradation/Type	Separation Geotextile
>35% passing No. 200 Sieve	Warranted
≤35% passing No. 200 Sieve	Not Warranted

4. Placement of Geogrid Base Reinforcement in the Pavement Section

The position of the geogrid in the pavement section is important to the performance of the geogrid base reinforcement. The following notes regarding placement of the geogrid in the pavement section should be followed:

a) The minimum ABC thickness for use of geogrid in the pavement section is 6 inches.
b) For ABC thicknesses in the range of 6 to 18 inches, the geogrid should be placed at the interface between the subgrade and ABC.
c) For ABC thicknesses greater than 18 inches, geogrid is not recommended.

5. Construction Cost Analysis

A cost analysis should be performed to show the economic benefit of geogrid base reinforcement in the pavement design. The cost of utilizing geogrid base reinforcement to improve the mean design R-Value by 10, and thereby reducing the thickness of ABC and/or AC in the pavement design, should be compared to a cost analysis performed on the original design. The construction cost analysis for the design including base reinforcement geogrid must also include the cost of separation geotextile fabric if required.

MATERIAL SPECIFICATIONS

Geogrid shall conform to Section 1014-3, Geogrid, of the ADOT Standard Specifications.

Separation geotextile fabric shall conform to Section 1014-4, Separation Geotextile Fabric, of the ADOT Standard Specifications.

CONSTRUCTION SPECIFICATIONS

Geosynthetics utilized for base reinforcement shall be placed as specified in Section 306, Geogrid Base Reinforcement, and Section 208, Separation/Stabilization Geotextile Fabric, of the ADOT Standard Specifications.

APPENDIX R: GUIDELINES FOR THE USE OF GEOGRID AND GEOTEXTILE FOR SUBGRADE STABILIZATION

GUIDELINES FOR THE USE OF GEOGRID AND GEOTEXTILE FOR SUBGRADE STABILIZATION

Introduction

These guidelines have been developed primarily to aid pavement design and construction engineers in implementation of geosynthetics, such as geogrids and geotextiles, in the pavement design process or during construction when soft subgrade soils are expected or are encountered. Other alternatives for subgrade stabilization such as lime treatment, cement treatment, or replacement with stable or drier soils should also be considered.

In stabilization design, the goal is to determine the aggregate thickness required to stabilize the subgrade and provide an adequate roadbed or stable platform for construction expedience using unreinforced or geosynthetic-reinforced aggregate. If geosynthetics are utilized, they are placed directly on the subgrade, prior to placement of the required thickness of aggregate for stabilization.

Design Method

The following design method was developed by Steward, Williamson, and Mohney (1977) for the United States Forest Service (USFS) for unpaved roadways, with some recommended modifications based on review of various design procedures. The basis for this guideline is the assumption that geotextiles may be used for subgrade stabilization in the same manner as they are for unpaved roadways.

This unpaved roadway design procedure assumes 50 to 100 mm (2 to 4 inches) of rut, but less than 2 inches of rut is generally acceptable during construction of paved roads. Once the stabilized lift is completed, construction proceeds utilizing the recommended pavement design. Therefore, subgrade stabilization is for expedience in construction, to allow the use of construction equipment on a soft or saturated subgrade with low cohesion. If the subgrade is hard, no stabilization would be necessary even if the R-Value was low. The cost-effectiveness is determined by the thickness of the base course needed to stabilize the subgrade prior to placing the base course for structural support necessary as part of the AASHTO pavement design. The thicker the base course is, the greater the cost will be.

The design process for subgrade stabilization involves utilizing the geogrid or geotextile, or geogrid and geotextile, to reduce the required thickness of replacement ABC to stabilize the subgrade. The design process should result in less than 2 inches of rut at the top of the replacement ABC, which would be the finished subgrade elevation. Although the design process does not address movement due to pumping at the top of the replacement ABC, the design process should minimize the potential for pumping at subgrade elevation. For compaction of asphaltic concrete, pumping is more of a concern than rut depth, especially if the design ABC thickness for the pavement section is less than 12 inches.

For soft subgrade with a shear strength in the range of 250 to 1000 psf (1.74 to 6.94 psi), both subgrade stabilization and base reinforcement applications are mobilized. For this subgrade strength level, either a nonwoven geotextile with geogrid or woven stabilization geotextile is recommended. Also, the aggregate thickness for subgrade stabilization can be reduced using the appropriate reinforced bearing capacity factor in the design procedure.

For subgrade with a shear strength in the range of 1000 to 1500 psf (6.94 to 10.42 psi), the use of a nonwoven geotextile for separation is generally recommended for fine-grained subgrades. A nonwoven

geotextile should also be used for separation when the designer has experienced separation problems with the construction materials during construction. It is recommended that the designer use bearing capacity factors for the inclusion of geogrid, nonwoven geotextile, woven geotextile, and geogrid with nonwoven geotextile as provided in the design procedure. The aggregate thickness for subgrade stabilization can be reduced using the appropriate reinforced bearing capacity factor in the design procedure.

Stabilization is not normally required for subgrade with a shear strength of over 1500 psf (10.42 psi).

The step-by-step design procedure is as follows:

1. Determine the subgrade soil strength. The subgrade shear strength, c, in psi is directly measured by a portable field vane shear test (ASTM D2573), or may be determined by correlation with a field CBR (ASTM D4429) or dynamic cone penetrometer (DCP) cone index test (ASTM D6951). Figure R-1 allows conversion from CBR (%) or cone index (mm/blow) to shear strength (c) in psi.

2. Make the strength determinations at several locations where the subgrade soils appear weakest. Strength should be evaluated over the depth ranges of 0 to 9 inches and 9 to 18 inches, taking six to 10 measurements at each location to obtain a good average value.
3. Determine the bearing capacity factors to be used according to Table R-1:

Table R-1. Stabilization Alternative vs. Bearing Capacity Factor (USACE 2003)

Stabilization Alternative	Bearing Capacity Factor, N_C
Unreinforced Aggregate	2.8
Aggregate with Geogrid	5.8
Aggregate with Woven Geotextile	5.0
Aggregate with Nonwoven Geotextile	3.6
Aggregate with Geogrid and Nonwoven Geotextile	5.8

4. Determine the values of c N_C by multiplying the average c values by the applicable bearing capacity factor, N_C. Enter the values for c N_C into the graphs in Figures R-2 and R-3 to determine the required aggregate thicknesses for unreinforced aggregate, aggregate with geogrid, aggregate with woven geotextile, or aggregate with nonwoven geotextile.
5. Select the required aggregate thickness for each alternative to the next higher 1 inch.
6. Perform an economic analysis of each alternative to determine which is most cost-effective. This may be accomplished using historical cost data for aggregate in place, geogrid installed, woven or nonwoven geotextile installed, and geogrid with nonwoven geotextile installed.
7. If a reinforced aggregate alternative is chosen, specify the geosynthetic material to be utilized. The material specifications for geogrid, woven geotextile, and nonwoven geotextile are in the ADOT Standard Specifications for Roadway and Bridge Construction as described in the next section.

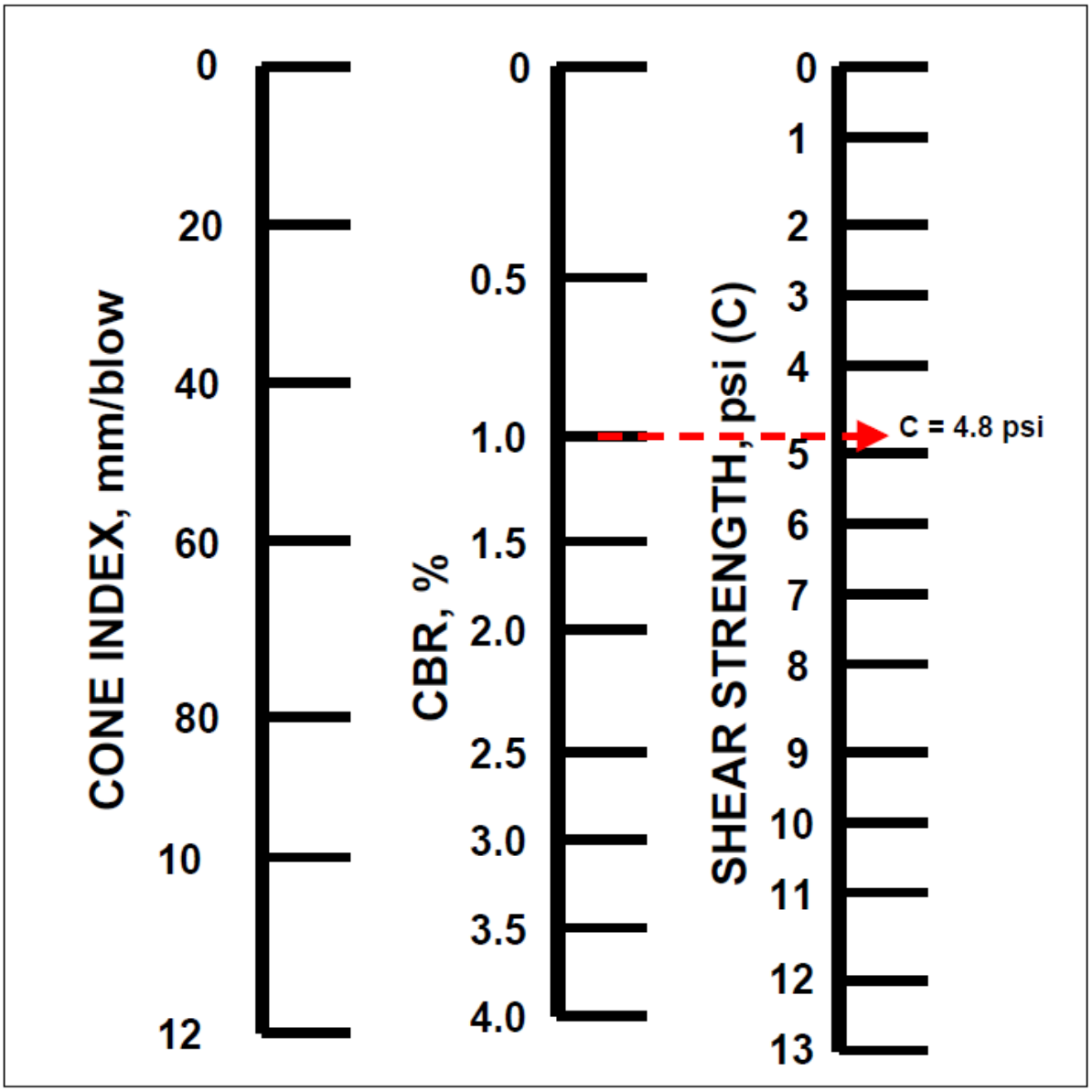

Figure R-1. Relationship between cone index, CBR, and shear strength (c) (TM 5-518-8) (US Department of the Army, US Department of the Air Force 1995)

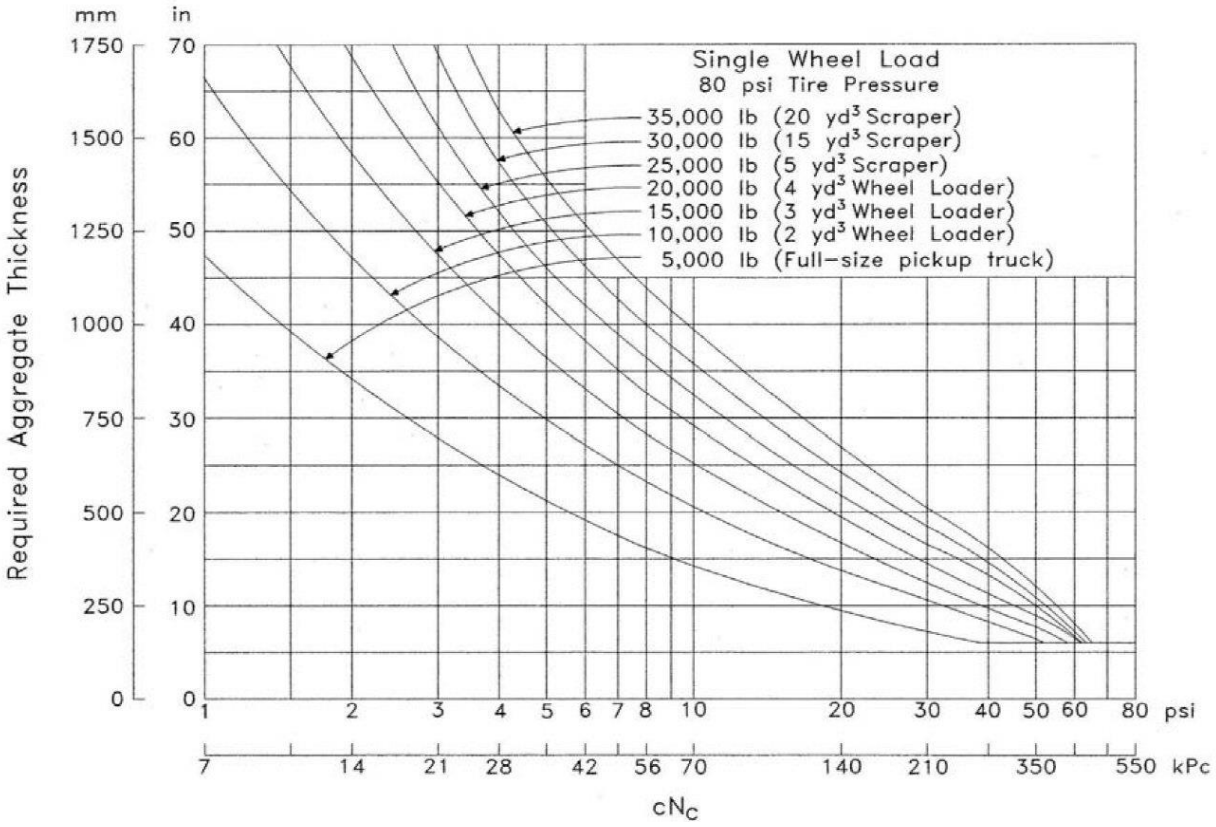

Figure R-2. Aggregate Thickness – Single Wheel Load (Steward et al. 1977)

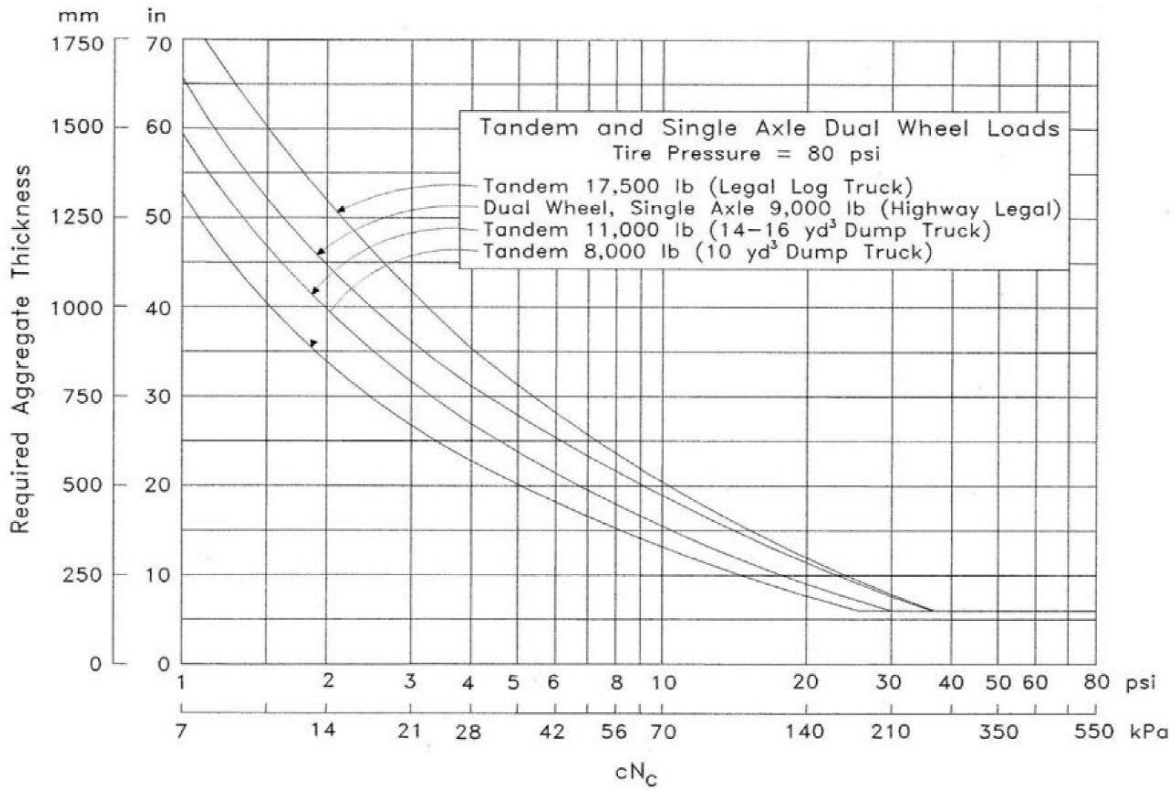

Figure R-3. Aggregate Thickness – Tandem and Single Axle Dual Wheel Loads (Steward et al. 1977)

Material Specifications

Aggregate shall conform to Class 2 in Table 303-1 of the ADOT Standard Specifications.

Geogrid shall conform to Section 1014-3, Geogrid, of the ADOT Standard Specifications.

Woven Geotextile shall conform to Section 1014-10, Stabilization Fabric, of the ADOT Standard Specifications.

Nonwoven Geotextile shall conform to Section 1014-10, Stabilization Fabric, of the ADOT Standard Specifications.

When geotextile is used together with geogrid in a subgrade stabilization application, the geotextile shall conform to Section 1014-4.02, Moderate Survivability Fabric, of the ADOT Standard Specifications.

Construction Specifications

Geosynthetics utilized for subgrade stabilization shall be placed as specified in Section 306, Geogrid Base Reinforcement, and Section 208, Separation/Stabilization Geotextile Fabric, of the ADOT Standard Specifications.

APPENDIX S: INDUSTRY SURVEY DOCUMENTS

Chalmers Engineering Services, Inc.
1451 North El Camino Drive
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May 21, 2015

Mr. Boyd Ramsey
GMA Executive Council Chairman
GSE Environmental
19103 Gundle Road
Houston, TX 77073
(281) 230-2598
bramsey@gseworld.com

RE: Arizona Department of Transportation
Geosynthetics: Specifications and Applications

Dear Mr. Ramsey,

The Arizona Department of Transportation (ADOT) has undertaken a research project regarding its use of geosynthetics in transportation infrastructure. Chalmers Engineering Services, Inc. is the consultant that has been contracted by ADOT to perform the research. The objectives of the project are to (1) update material specifications, (2) develop and document design guidelines for the use of geosynthetics for base reinforcement, and (3) develop and document design guidelines for the use of geosynthetics for subgrade stabilization.

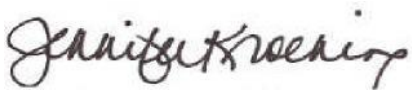
As part of the research project, ADOT would like to obtain feedback from the geosynthetics industry regarding the draft specifications and design guidelines. This feedback will help ADOT determine how to move forward with updating material specifications and design guidelines for geosynthetics. Four documents are attached: (1) study background summary, (2) draft geosynthetic specifications, (3) draft design guidelines for base reinforcement with geogrid, and (4) draft design guidelines for subgrade stabilization with geosynthetics.

Please send the attached draft specifications and design guidelines to your members. Ask your members to submit comments regarding the draft specifications and design guidelines to you. Compile the comments that you receive and send them to me at jkroening@chalmersengineering.com. In order to avoid individual manufacturers submitting comments biased towards their particular products, ADOT has requested that manufacturers not submit comments directly to us. Please send all comments by June 5, 2015.

Please note that the draft specifications and design guidelines represent the results of the research project and recommendations of the consultant only. ADOT is in no way obligated or committed to implement any of the recommendations.

Thank you for your time and attention.

Sincerely,



Jennifer Kroening, P.E.
Project Manager
(480) 540-9824 | jkroening@chalmersengineering.com

Attachments:
- Study Background
- Draft 1014 Geosynthetics Material Specifications
- Draft Guidelines for the Use of Geogrid for Base Reinforcement and Geotextile Separation Fabric
- Draft Guidelines for the Use of Geogrid and Geotextile for Subgrade Stabilization

Chalmers Engineering Services, Inc.
1451 North El Camino Drive
Tempe, AZ 85281

May 21, 2015

James Collin, Ph.D.
Geosynthetics Technical Committee Chair, ASCE Geo-Institute
The Collin Group Ltd.
7445 Arlington Roads
Bethesda, MD 20814
(301) 907-9501
jim@thecollingroup.com

RE: Arizona Department of Transportation
Geosynthetics: Specifications and Applications

Dear Dr. Collin,

The Arizona Department of Transportation (ADOT) has undertaken a research project regarding its use of geosynthetics in transportation infrastructure. Chalmers Engineering Services, Inc. is the consultant that has been contracted by ADOT to perform the research. The objectives of the project are to (1) update material specifications, (2) develop and document design guidelines for the use of geosynthetics for base reinforcement, and (3) develop and document design guidelines for the use of geosynthetics for subgrade stabilization.

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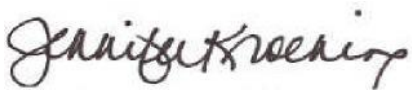

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1451 North El Camino Drive
Tempe, AZ 85281

May 21, 2015

Mr. John Henderson
President, NAGS
TenCate Geosynthetics Americas
365 South Holland Drive
Pendergrass, GA 30567
(706) 693-1836
j.henderson@tencate.com

RE: Arizona Department of Transportation
Geosynthetics: Specifications and Applications

Dear Mr. Henderson,

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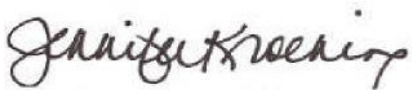

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The ADOT material specifications for geosynthetics have not been updated in many years. Several of the referenced test methods and requirements are no longer consistent with industry specifications and test methods, specifically as documented in AASHTO M288. Development of updated draft material specifications involved surveying other states regarding their specifications and reviewing current industry specifications and test methods. The draft specifications were developed to generally align with AASHTO M288 requirements and test methods.

ADOT has been using geosynthetics, specifically geogrid, for base reinforcement for more than 20 years. ADOT reports that their design procedure has produced satisfactory results based on anecdotal evidence. ADOT not performed any testing to verify the benefits of their design procedure. In addition, the design procedure and considerations for using geogrid for base reinforcement have never been fully documented. Development of the draft design guidelines for using geosynthetics for base reinforcement involved reviewing available industry design procedures, other state design guidelines for base reinforcement, and performance related study data. The draft design guidelines for base reinforcement were developed to document ADOT's existing design procedure for using geogrid for base reinforcement and to expand on it by incorporating recommendations and guidance from available industry design procedures.

ADOT does not have any documented process for using geosynthetics for subgrade stabilization. ADOT is interested in evaluating the use of geosynthetics for subgrade stabilization as an alternative to other methods of subgrade stabilization such as lime stabilization, cement stabilization, and over excavation. Development of the draft design guidelines for using geosynthetics for subgrade stabilization involved reviewing available industry design procedures, other state design guidelines for subgrade stabilization, and performance related study data. The draft design guidelines were developed to reflect available industry design procedures and practices.

The draft specifications and design guidelines will assist ADOT in the selection and use of geosynthetic products. As part of the research project, ADOT would like to obtain feedback from the geosynthetics industry regarding the draft specifications and design guidelines. This feedback will help ADOT determine how to move forward with updating material specifications and design guidelines for geosynthetics. ADOT has identified three industry organizations to share the draft documents with; the North American Geosynthetics Society (NAGS), the Geosynthetics Materials Association (GMA), and the American Society of Civil Engineers (ASCE) – Geo-Institute (G-I). ADOT is requesting that each organization share the draft documents with their members for the purpose of collecting feedback on the draft documents to report back to ADOT.

It should be noted that the draft specifications and design guidelines represent the results of the research project and recommendations of the consultant only. ADOT is in no way obligated or committed to implement any of the recommendations.

GUIDELINES FOR THE USE OF GEOGRID FOR BASE REINFORCEMENT AND GEOTEXTILE SEPARATION FABRIC

GUIDELINES FOR THE USE OF GEOGRID AND GEOTEXTILE FOR SUBGRADE STABILIZATION

APPENDIX T: INDUSTRY SURVEY COMMENTS

Jennifer Kroening

From: Jim Collin <jim@thecollingroup.com>
Sent: Wednesday, June 10, 2015 11:22 AM
To: Jennifer Kroening
Cc: zornberg@mail.utexas.edu; 'Stephanie Huang'; Mark Wayne; Keaton Botelho; Murad Abu-Farsakh Ph. D. (cefars@lsu.edu)
Subject: Re: Arizona DOT: Geosynthetics Specifications and Design Guidelines (ASCE G-I)
Attachments: ADOT Review by ASCE G-I Geosynthetics Committee_060915[1].pdf

Jennifer,
Attached are the GI Geosynthetics Committee review comments. Thanks you for the opportunity to provide a review. If you have any questions please do not hesitate to contact us.
Regards,
Jim

James G. Collin Ph.D., P.E., D.GE., F. ASCE
The Collin Group, Ltd.
7445 Arlington Road
Bethesda, MD 20814

O: 301.907.9501
C: 301.442.7182

www.thecollingroup.com

The following comments apply to the "Arizona Department of Transportation Geosynthetics: Specifications and Applications." The review comments are provided in relation to the three sections of this draft document provided to the ASCE G-I Geosynthetics Committee with a draft date of May 21, 2015. The committee will gladly answer any additional questions that may result from the consultant's review of these comments.

The committee has examined this document and it appears as though there are three distinct sections. These include: Section 1014 Geosynthetic Specifications (pages 1-15), Guidelines for the use of geogrid for base reinforcement and geotextile separation fabric and (Pages 1-3) and Guidelines for the use of geogrid and geotextile for subgrade stabilization (Pages 1-5). The review yielded the following comments, questions and concerns. Where possible suggestions are provided for your review. Reference materials can be provided upon request.

Section 1014 Geosynthetic Specifications - comments, questions and concerns:

1. It seems most of the specifications (pages 1-15) are derived from "Standard Specification for Geotextile Specification for Highway Applications AASHTO Designation M288 and FHWA Geosynthetic Design & Construction Guidelines Reference Manual. Yet some of the guidance in the ADOT draft differs from this guidance. We would recommend that the consultant review these documents along with the "Standard Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures AASHTO Designation: R50-09".
2. Section 1014-1:
    a. **Section 1014-1** Manufacturer's issue product certification letters for their products which include results of their respective quality assurance program. As such please consider revising "certificates of Analysis". If you need an example of these documents please let us know.
    b. **Section 1014-1** Is there a section on definitions? Is the "Engineer" defined somewhere?
    c. **Section 1014-1** The wording regarding the shipping and handling of materials is no longer needed in this document. ASTM D4873-15 "Standard guide for Identification, Storage and Handling of Geosynthetic Rolls and Samples" covers the statements made in this section and users can be instructed to follow these guidelines.
    d. **Section 1014-1** This document indicates that geotextile requirements shall be "generally" in accordance. This is difficult word and we recommend the wording as follows: "shall be in accordance with Standard Specification for Geotextile Specification for Highway Applications AASHTO Designation M288 unless otherwise approved by the engineer. Further the word fabric is used throughout and we would suggest that for everything but paving the word "fabric" be removed from this document.
    e. The ultimate elongation % in the Table within **Section 1014-2** should be greater than or equal to 50% in accordance with M288.
    f. The material statement in **Section 1014-2** regarding chemical attack, rot and mildew should be removed. The first paragraph covers all that is needed in the specification and mirrors M288.
    g. **Section 1014-3:** As currently written, the draft specification references "bi-axial" geogrid, with no mention of other geogrid types. Multi-axial geogrids are also available in the market; approximately 40 US states currently allow use of Tensar's TriAx geogrid,

for example. As such, 1014-3 should be supplemented with language that allows multi-axial geogrids. Two routes are commonly available for such inclusion:

i. Incorporate directly via wording such as *The geogrid shall be a grid structure consisting of a continuous sheet of polypropylene material that is "punched and stretched" to create an integrally formed grid structure with a high tensile modulus, open apertures (rectangular or triangular), and thick ribs and junctions to permit significant mechanical interlock with the material being reinforced and with continuity of tensile strength through all ribs and junctions of the structure. The geogrid shall maintain its reinforcement and interlock capabilities under repeated dynamic loads while in service and shall also be resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced.* [Source, Section 6-4-D, NMDOT Geogrid Base Reinforcement Specification)

Incorporate indirectly by adding language allowing Alternate Geogrids. The following wording could be used:

ii. Alternate geogrid materials maybe considered for a specific project based on documented performance, however, it is recommended that such materials be approved in writing by the Engineer at least 15 days prior to bid date. In order to help the Engineer determine the appropriateness of alternative geogrid products, it is suggested that product manufacturers include within their submittal packages the following information:

1. Full scale laboratory testing and in-ground testing of roadbed structures stabilized with the specific geogrid which quantifies the structural contribution of the geogrid to the roadbed structure in accordance with AASHTO Designation: R50-09. The performance benefit of the alternative geogrid must meet or exceed that of the geogrid originally specified.
2. A list of five comparable projects, in terms of size and application where the results of the specific alternative geogrid use can be verified after a minimum of 1 year of service life.

h. The table of required geogrid properties in 1014-3 should be revised to match the requirements of the draft ADOT subgrade stabilization guide. Table 1 of that guide shows a bearing capacity factor for "aggregate with geogrid" of 5.8. It should be noted that this factor was developed by the US Army Corps of Engineers (US Army Corps of Engineers ETL 1110-1-189, 2002, *Use of Geogrids in Pavement Construction*) and calibrated by field research (Tingle and Webster, 2003, *Review of Corps of Engineers Design of Geosynthetic Reinforced Unpaved Roads*) and that the factor was based on a specific geogrid type, and as such, the table of required values in 1014-3 should be upgraded to reflect that geogrid type. The suggested table is as follows:

Biaxial Geogrid

Property	Test	Value
Aperture size, inch[a] min and max	Calipered	0.8-1.3 x 1.0-1.6
Rib thickness, inch min	Calipered	0.04
Junction thickness, inch min	Calipered	0.150
Tensile strength, 2% strain, lb/ft[a] min	ASTM D 6637	410 x 620
Tensile strength at ultimate, lb/ft[a] min	ASTM D 6637	1,310 x 1,970
Ultraviolet resistance, percent min retained tensile strength, 500 hours	ASTM D 4355	100
Junction efficiency (%)[b]	ASTM D 7737	93
Overall flexural rigidity, mg-cm min	ASTM D 7748	750,000
Aperture Stability Modulus at 20 cm-kg, mm-kg/deg[c] min	ASTM D 7864	0.65

[a]Machine direction x cross direction

[b]Load transfer expressed as a percentage of ultimate rib tensile strength in the same direction as the junction test (determined in accordance with ASTM D6637).

i. The permittivity tables throughout **Section 1014** differ from AASHTO Designation M288 in that there should be function specific values. Please see M288 for wording and recommended values.

j. **Section 1014-6** The statement ...geocomposite shall be resistant to commonly encountered chemicals and hydrocarbons, and resistant to ultraviolet exposure." Seems like it is left undefined. A UV test on the geotextile alone should be considered.

k. **Section 1014-6.01** The statement "...core shall have at least 14 square inches per square foot of flat area in contact with the geotextile fabric to support the fabric." seems like it would be difficult to confirm. Should this be qualitative instead of quantitative?

l. **Section 1014-6.01** Table transmissivity value is specified at 14.5 psi (2088 psf) in the industry utilized specifiers guide. Is there a reason this value was selected?

m. **Section 1014-6.01** mentions the geotextile but not the requirements for the geotextile. Perhaps reference is required to a particular class of geotextile? And a particular permittivity value.

n. **Section 1014-7.03** Outlet Pipes contains one set pipe diameter. Is it necessary to specify the diameter in the specifications? This should be based on the design flow rates and site specific conditions.

o. **Section 1014-8** The statement “Sheets of fabric may be sewn or bonded together.” Requires clarification regarding approved bonding methods, and approved seaming methods.
p. **Section 1014-9** Should be titled Subsurface Drainage Geotextile and the AOS Table 2 from AASHTO Designation M288 should be inserted here as AOS is a function of soil in contact with the geotextile.

Guidelines for the use of geogrid for base reinforcement and geotextile separation fabric - comments, questions and concerns:

1. For alternate materials we would recommend that the consultant consider reviewing the “Standard Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures AASHTO Designation: R50-09” and “FHWA Geosynthetic Design & Construction Guidelines Reference Manual.” The benefit of a geogrid should be a function of subgrade strength/stiffness condition, thickness of base aggregate layer, and properties of geogrid used. If ADOT is interested in full evaluation of these alternate products then consideration for full scale APT on control and geogrid sections should be performed in accordance with APT guidelines as established by NCHRP Report 512 Accelerated Pavement Testing: Data Guidelines.
2. For step 4c: the review committee does not agree with the recommendation of not using geogrid for ABC thickness greater than 18 inches. For 18 inches of ABC over a weak subgrade, we would recommend placing one geogrid layer at the upper one third location for which research has shown a significant benefit.

Guidelines for the use of geogrid and geotextile for subgrade stabilization - comments, questions and concerns:

1. The design methodology proposed in the draft guide utilizes Stewart et al. (1977) as its basis. The Steward et al. methodology was an empirical approach developed exclusively for geotextiles and for large rut depths (2 to 4 inches). Since neither limitation fits the stated objectives of the design guide, the Giroud-Han (2004) methodology is suggested for inclusion in the draft guide. This design approach, which is both theoretically-based and empirically calibrated, takes into account the distribution of stresses, strength of the base course material, geogrid-aggregate interlock, and geogrid in-plane stiffness, in addition to loading conditions. Importantly, use of the Giroud-Han (2004) methodology can incorporate a wide variety of geogrid types, once those types have been properly calibrated.
2. As per the previous comment herein related to the 1014 specification, Table 1 of the draft guide shows a bearing capacity factor for “aggregate with geogrid” of 5.8. This factor was developed by the US Army Corps of Engineers (US Army Corps of Engineers ETL 1110-1-189, 2002, *Use of Geogrids in Pavement Construction*) and calibrated by field research (Tingle and Webster, 2003, *Review of Corps of Engineers Design of Geosynthetic Reinforced Unpaved Roads*) and that the factor was based on a specific geogrid type, and as such, the table of required values in 1014-3 should be upgraded to reflect that geogrid type. (suggested table provided previously herein).

The ASCE G-I Geosynthetic Committee thanks you for allowing us to provide this valuable input. Please feel free to contact with any requests for additional support documentation or questions on the information we have provided in this response.

Jennifer Kroening

From: Jonathan I. Curry <jicurry@ifai.com>
Sent: Friday, June 12, 2015 6:46 AM
To: Jennifer Kroening
Cc: Keith Gardener; Fred Chuck Gmail; Doug Brown; Boyd Ramsey
Subject: RE: Arizona DOT: Geosynthetics Specifications and Design Guidelines (GMA)
Attachments: GMA Comments_AZ DOT_Spec Proposal with comments 2015_06_12.pdf

Importance: High

Jennifer,

On behalf of the Geosynthetic Materials Association I would like to thank the Arizona DOT for the opportunity to comment on the draft specifications and design guidelines for the use of geosynthetics. Please do not hesitate to reach out to me if you have any questions in regards to our comments.

Have a great weekend.

Jon

CC:
Keith Gardner– Chairman
Fred Chuck – 1st Vice Chair
Doug brown – 2nd Vice Chair
Boyd Ramsey– Past Chairman

Jonathan Curry
DIVISION SUPERVISOR, GMA
+1651 225 6956
jicurry@ifai.com
Industrial Fabrics Association International
1801 County Road B West // Roseville MN 55113 // IFAI.com

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Comment [FC1]: Clarify version of M288. Latest is M288-06 (Skaps)

ADOT has been using geosynthetics, specifically geogrid, for base reinforcement for more than 20 years. ADOT reports that their design procedure has produced satisfactory results based on anecdotal evidence. ADOT not performed any testing to verify the benefits of their design procedure. In addition, the design procedure and considerations for using geogrid for base reinforcement have never been fully documented. Development of the draft design guidelines for using geosynthetics for base reinforcement involved reviewing available industry design procedures, other state design guidelines for base reinforcement, and performance related study data. The draft design guidelines for base reinforcement were developed to document ADOT's existing design procedure for using geogrid for base reinforcement and to expand on it by incorporating recommendations and guidance from available industry design procedures.

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SECTION 1014 GEOSYNTHETICS: of the Standard Specifications is revised to read: **1014-1 General Requirements:**

Certificates of Compliance, conforming to the requirements of Subsection 106.05, shall be submitted to the Engineer by the contractor upon delivery of geosynthetic materials for use on a specific project. If the delivered materials have not been evaluated and preapproved as noted below, it will be necessary for a Certificate of Analysis to be submitted to the Engineer along with the supporting documentation before the material may be considered for use on the project. Each geosynthetic material lot or shipment must be approved by the Engineer before the materials may be incorporated in the work.

Certificates of Analysis, conforming to the requirements of Subsection 106.05, may be submitted, along with a representative sample of appropriate size for testing, by the supplier or manufacturer of any geosynthetic material to ADOT Materials Group for evaluation and preapproval. Testing methods and results shown in the Certificate of Analysis shall conform to the listed specifications for the proposed geosynthetic use. Supporting documentation including, but not limited to, product information sheets, installation procedures and recommendations, recommended use, and project references shall also be submitted by the supplier or manufacturer as part of product evaluation and preapproval.

Comment [FC2]: In liew of the Certificates of Compliance and Analysis, the AZ DOT should consider adapting the NTPEP GTX-01-15 Audit Plan for complaint manufacturers and private labelers. Language could include following: "Geotextiles must be tested by the AASHTO National Transportation Product Evaluation Program (NTPEP). Effective with the 2015 publication of Section 1014: Geosynthetics, all manufacturers of geotextiles must participate in and maintain compliance with the NTPEP GTX-01-15 audit program. Geotextiles provided to AZDOT projects after July 1, 2015 must be clearly printed with identifying information as described in the NTPEP audit work plan."

Geosynthetic materials shall be furnished in protective covers capable of protecting the materials from harmful environmental conditions such as ultraviolet rays, abrasion, extreme heat, and water. Storage of the materials will be in a manner to prevent damage, contamination, or deterioration of the materials.

Samples of geosynthetic materials shall be submitted for testing. No samples shall be taken within five feet of either end of a roll. Samples shall be a minimum of six feet long by the full roll width. A minimum of one sample shall be taken per lot. More samples may be required as determined by the Engineer.

Requirements for pavement fabric, separation geotextile fabric, bank protection fabric, temporary silt fence fabric, drainage fabric, and stabilization fabric are generally in accordance with AASHTO M288.

1014-2 Pavement Fabric:

Pavement fabric shall meet the requirements specified below.

Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

The pavement fabric shall be resistant to chemical attack, rot, and mildew, and shall have no tears or defects which will adversely alter its physical properties. The fabric shall be specifically designed for the designated pavement application, as a stress relieving membrane between two successive asphalt layers.

The width of the fabric shall be appropriate for the proposed construction.

Property	Requirement (Note 1)	Test Method
Mass per unit area: oz./sq. yd. (g/m^2)	4.0 (140)	ASTM D 5261
Grab strength: lbs. (N)	100 (450)	ASTM D 4632
Ultimate elongation: %	50	ASTM D 4632
Melting point: degrees F (degrees C)	300 (150)	ASTM D 276
Asphalt Retention: gal./sq. yd. (L/m^2)	(Notes 2 and 3)	ASTM D 6140
Notes: (1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction. (2) Asphalt required to saturate paving fabric only. Asphalt retention must be provided in manufacturer certification. Value does not indicate the asphalt application rate required for construction. (3) Product asphalt retention property must meet the MARV value provided by the manufacturer certification.		

1014-3 Geogrid:

Geogrid reinforcement material for roadway base applications shall be a bi-axial polymer grid structure, specifically fabricated for use as a base reinforcement. The width of the geogrid shall normally be approximately 13 feet or as appropriate for the proposed construction. The geogrid shall be one of the following structure types:

(A) A structure comprised of punched and drawn polypropylene sheet to form a grid.

(B) A structure comprised of polypropylene extruded to form a grid.

(C) A structure comprised of polypropylene integrally formed by extruding then stretching longitudinally and transversely to form a grid.

The geogrid material shall additionally conform to the following physical requirements:

Property	Requirement	Test Method
Average Aperture Size: inch (mm) MD, **(Note 2)** XD, **(Note 3)**	 0.8 - 1.4 (20 - 35) 0.8 - 1.4 (20 - 35)	I.D. Calipered, **(Note 1)**
Tensile Strength: lb./ft. (N/m) At 2% Strain At 5% Strain At 15% Strain	 400 (542) min. 800 (1084) min. 1300 (1762) min.	ASTM D 6637
Junction Efficiency: %	93 min.	ASTM D 7737
Notes: (1) Maximum inside dimension in each principal direction measured by calipers. (2) MD-Machine direction which is along roll length. (3) XD-Cross machine direction which is across the roll width.		

Comment [FC3]: This does not allow for grids with bonded junctions (NAGS)

Comment [FC4]: As currently written, the draft specification references "bi-axial" geogrid, with no mention of other geogrid types. Multi-axial geogrids are also available in the market. As such, 1014-3 should be supplemented with language that allows multi-axial geogrids. Two routes are commonly available for such inclusion:

a. Incorporate directly via wording such as *The geogrid shall be a grid structure consisting of a continuous sheet of polypropylene material that is "punched and stretched" to create an integrally formed grid structure with a high tensile modulus, open apertures, and ribs and junctions to permit significant mechanical interlock with the material being reinforced and with continuity of tensile strength through all ribs and junctions of the structure. The geogrid shall maintain its reinforcement and interlock capabilities under repeated dynamic loads while in service and shall also be resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced.* [Source, Section 6-4-D, NMDOT *Geogrid Base Reinforcement* Specification)

b. Incorporate indirectly by adding language allowing Alternate Geogrids. For example; i. **Alternate geogrid materials** may be considered for a specific project based on documented performance, however, it is recommended that such materials be approved in writing by the Engineer at least 15 days prior to bid date. In order to help the Engineer determine the appropriateness of alternative geogrid products, it is suggested that product manufacturers include within their submittal packages the following information: 1. Full scale laboratory testing and in-ground testing of roadbed structures stabilized with the specific geogrid which quantifies the structural contribution of the geogrid to the roadbed structure in accordance with AASHTO Designation: R50-09. The performance benefit of the alternative geogrid must meet or. Exceed that of the geogrid originally specified. (Tensar)

Comment [FC5]: Alternate geogrid materials should be accepted based on documented independent, published performance with the product identified by independent index tests and compared side by side with a product that meets the values of 1014-3 Geogrid (Hanes)

(Tensar)

2. The table of required geogrid properties in 1014-3 should be revised to match the requirements of the draft ADOT subgrade stabilization guide. Table 1 of that guide shows a bearing capacity factor for "aggregate with geogrid" of 5.8. This factor was developed by the US Army Corps of Engineers (US Army Corps of Engineers ETL 1110-1-189, 2002, *Use of Geogrids in Pavement Construction*) and calibrated by field research (Tingle and Webster, 2003, *Review of Corps of Engineers Design of Geosynthetic Reinforced Unpaved Roads*) and the factor was based on a specific geogrid type - as such, the table of required values in 1014-3 should be upgraded to reflect that geogrid type. The suggested table is as follows:

Biaxial Geogrid

Property	Test	Value
Aperture size, inch[a] min and max	Calipered	0.8-1.3 x 1.0-1.6
Rib thickness, inch min	Calipered	0.04
Junction thickness, inch min	Calipered	0.150
Tensile strength, 2% strain, lb/ft[a] min	ASTM D 6637	410 x 620
Tensile strength at ultimate, lb/ft[a] min	ASTM D 6637	1,310 x 1,970
Ultraviolet resistance, percent min retained tensile strength, 500 hours	ASTM D 4355	100
Junction efficiency (%)[b]	ASTM D 7737	93
Overall flexural rigidity, mg-cm min	ASTM D 7748	750,000
Torsional rigidity at 20 cm-kg, mm-kg/deg[c] min	GRI:GG9	0.65

[a]Machine direction x cross direction
[b]Load transfer expressed as a percentage of ultimate rib tensile strength in the same direction as the junction test (determined in accordance with ASTM D6637).
[b]Geosynthetic Research Institute, Test Method GG9, *Torsional Behavior of Bidirectional Geogrids When Subjected to In-Plane Rotation*

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Comment [FC6]: Some of the specifications in this table would not allow for grids with bonded junctions (NAGS)

Comment [FC7]: Junction thickness probably not needed as Junction efficiency should cover this. (Hanes)

1014-4 Separation Geotextile Fabric:

Separation fabric shall meet the requirements specified below.

Fibers, yarns and filaments used in the manufacture of geotextiles, and the threads used in joining geotextiles by
sewing, shall consist of long-chain synthetic polymers, composed of at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

The fabric shall be inert to commonly encountered chemicals, resistant to rot and mildew, and shall have no tears or defects which adversely affect or alter its physical properties. The physical requirements for the separation fabric will be determined by the survivability rating called out for the fabric in the Special Provisions or as shown on the project plans. Requirements for each survivability rating are listed in Subsections 1014-4.01, 1014-4.02, and 1014-4.03.

Comment [FC8]: "yarns and filaments" should be added to each section the includes specifications for both wovens and non-wovens (Skaps)

1014-4.01 Low Survivability Fabric:

Low survivability fabric shall meet the following strength requirements:

Property	Requirement (Note 1)		Test Method
	Class 3 Woven	Class 3 Non-Woven	
	Elongation <50% (Note 2)	Elongation ≥50% (Note 2)	
Grab strength: lbs. (N)	180 (800)	112 (500)	ASTM D 4632
Sewn seam strength: lbs. (N)	162 (720)	101 (450)	ASTM D 4632
Tear strength: lbs. (N)	67 (300)	40 (180)	ASTM D 4533
Puncture strength: lbs. (N)	371 (1650)	223 (990)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure		ASTM D 4355

Notes:
(1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction.
(2) As measured in accordance with ASTM D 4632.

Low survivability fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.02	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 30 (0.60)	ASTM D 4751

Note:
(1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.

1014-4.02 Moderate Survivability Fabric:

Moderate survivability fabric shall meet the following strength requirements:

Property	Requirement (Note 1)		Test Method
	Class 2 Woven Elongation <50% (Note 2)	Class 2 Non-Woven Elongation ≥50% (Note 2)	
Grab strength: lbs. (N)	247 (1100)	157 (700)	ASTM D 4632
Sewn seam strength: lbs. (N)	223 (990)	142 (630)	ASTM D 4632
Tear strength: lbs. (N)	90 (400) (Note 3)	56 (250)	ASTM D 4533
Puncture strength: lbs. (N)	495 (2200)	309 (1375)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure		ASTM D 4355

Notes:
(1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction.
(2) As measured in accordance with ASTM D 4632.
(3) The required MARV tear strength for woven monofilament geotextiles is 56 lbs. (250 N).

Moderate survivability fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.02	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 30 (0.60)	ASTM D 4751

Note:
(1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.

1014-4.03 High Survivability Fabric:

High survivability fabric shall meet the following strength requirements:

Property	Requirement (Note 1)		Test Method
	Class 1 Woven	Class 1 Non-Woven	
	Elongation <50% (Note 2)	Elongation ≥50% (Note 2)	
Grab strength: lbs. (N)	315 (1400)	202 (900)	ASTM D 4632
Sewn seam strength: lbs. (N)	283 (1260)	182 (810)	ASTM D 4632
Tear strength: lbs. (N)	112 (500)	79 (350)	ASTM D 4533
Puncture strength: lbs. (N)	618 (2750)	433 (1925)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure		ASTM D 4355
Notes: (1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction. (2) As measured in accordance with ASTM D 4632.			

High survivability fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.02	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 30 (0.60)	ASTM D 4751
Note: (1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.		

1014-5 Bank Protection Fabric:

Bank protection fabric shall meet the requirements specified below.
Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

The fabric shall be inert to commonly encountered chemicals, resistant to rot and mildew, and shall have no tears or defects which adversely affect or alter its physical properties.

Bank protection fabric shall meet the following strength requirements:

Property	Requirement (Note 1)	Test Method
	Class 1 Non-Woven	
	Elongation ≥50% (Note 2)	
Grab strength: lbs. (N)	202 (900)	ASTM D 4632
Sewn seam strength: lbs. (N)	182 (810)	ASTM D 4632
Tear strength: lbs. (N)	79 (350)	ASTM D 4533
Puncture strength: lbs. (N)	433 (1925)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure	ASTM D 4355

Notes:
(1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction.
(2) As measured in accordance with ASTM D 4632.

Bank protection fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.7	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 70 (0.22)	ASTM D 4751

Note:
(1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.

1014-6 Geocomposite Wall Drain System:

The Geocomposite Wall Drain System shall be of composite construction, consisting of a supporting structure of drainage core material and a geotextile filter fabric permanently bonded to the core material on one side only. The geocomposite shall be resistant to commonly encountered chemicals and hydrocarbons, and resistant to ultraviolet exposure.

1014-6.01 Geocomposite Wall Drain Core:

The wall drain core material shall consist of a preformed, stable, polymer plastic material with a cuspated, nippled, or geonet structure. The drainage core shall provide support for and shall be bonded to the geotextile filter fabric at intervals not exceeding 1-1/8 inches in any direction. Its preformed structure shall be perforated to allow water to flow freely to the weephole drainage outlets. If not perforated during manufacture, the core shall be perforated in the field at the weephole drainage outlet locations. The core shall have at least 14 square inches per square foot of flat area in contact with the geotextile fabric to support the fabric. The core material shall additionally conform to the following physical requirements:

Property	Requirement (Note 1)	Test Method
Thickness with fabric: inch (mm)	0.23 (5.8)	ASTM D 1777
Compressive Strength: psf (kN/m^2)	6,000 (287)	ASTM D 1621
Transmissivity; Gradient = 1.0, Normal Stress = 5000 psf (239 kN/m^2) gal./min./ft. (L/min./m)	4.0 (4.6)	ASTM D 4716
Note: (1) All numeric values represent minimum values.		

The geocomposite core shall be furnished with an approved method for connecting with outlet pipes or weepholes as shown on the plans. These fittings shall allow entry of water from the core, but shall not allow intrusion of backfill material into the core.

1014-6.02 Geocomposite Wall Drain Fabric:

The geotextile wall drain fabric shall be laminated onto or adhere to the side of the drainage core which will face the backfill. Geotextile wall drain fabric shall meet the requirements of Subsection 1014-9.

A minimum three-inch wide flap of geotextile fabric shall extend beyond both longitudinal edges of the geocomposite core. The geotextile fabric shall cover the full length of the core.

1014-7 Geocomposite Edge Drain System:

The Geocomposite Edge Drain System shall be of composite construction, consisting of a supporting rectangular structure of drainage core material wrapped with a geotextile filter fabric. The fabric shall surround and be attached to the core material in a manner which does not restrict the flow capacity of the core material. The geocomposite shall be resistant to commonly encountered chemicals and hydrocarbons, and resistant to ultraviolet exposure.

1014-7.01 Geocomposite Edge Drain Core:

The edge drain core material shall consist of a preformed, stable, polymer plastic material with a cuspated, nippled, ridged, slotted, and/or perforated structure. The drainage core shall provide support for and may be bonded to the geotextile filter fabric. Its preformed structure shall be perforated to allow water to flow freely to the weephole drainage outlets. If not perforated during manufacture, the core shall be perforated in the field at the weephole drainage outlet locations unless otherwise approved by the Engineer. The core shall have at least 14 square inches of flat area in contact with the geotextile fabric to support the fabric per square foot. The core material shall additionally conform to the following physical requirements:

Property	Requirement (Note 1)	Test Method
Thickness Wrapped with Fabric: inch (mm)	0.75 (19)	ASTM D 1777
Compressive Strength: psf (kN/m^2)	6,000 (287)	ASTM D 1621
Transmissivity; Fabric Wrapped Core, Gradient = 0.1, Normal Stress = 1440 psf (68.9 kN/m^2), gal./min./ft. (L/min./m)	4.0 (4.6)	ASTM D 4716, **(Note 2)**
Width: ft. (m)	1.0 (0.30) **(Note 3)**	Measured

Notes:
(1) All values represent minimum values.
(2) Use a full width panel, if possible, testing flow on the side which may be placed against the soil to be drained.
(3) Minimum width normally required, but shall be the minimum width specified on the plans, if that is greater.

1014-7.02 Geocomposite Edge Drain Fabric:

The geotextile edge drain fabric shall completely wrap around the drainage core material in a snug manner and may be permanently bonded to the core. Geotextile edge drain fabric shall meet the requirements of Subsection 1014-9.

1014-7.03 Outlet Pipes:

The pipe for the edge drain outlet lateral shall be rigid, four-inch diameter, Schedule 40 PVC pipe conforming to the requirements of ASTM D 1785, Schedule 40 polyethylene pipe conforming to the requirements of ASTM D 2104, or Schedule 40 ABS pipe conforming to the requirements of ASTM D 1527.

The open end of the outlet pipe conduit shall be connected into either a drainage structure or a concrete pad drain in accordance with the details shown on the plans.

1014-8 Temporary Silt Fence Fabric:

Temporary silt fence fabric shall meet the requirements specified below.
Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

The fabric shall contain a stabilizer and/or inhibitors to make the filaments resistant to deterioration resulting from exposure to sunlight or heat.

The edges of the fabric shall be finished to prevent the outer yarn from pulling away from the fabric. The fabric shall be free of defects or flaws which significantly affect its physical or filtering properties. The fabric shall have a minimum width of 36 inches. Sheets of fabric may be sewn or bonded together. No deviation from any physical requirements will be permitted due to the presence of the seam.

The fabric may be manufactured with pockets for posts, hems with cord or with posts preattached using staples or button head nails.

During all periods of shipment and storage, the fabric shall be wrapped in a heavy duty protective covering which will protect the cloth from sunlight, mud, dust, and debris. The fabric shall not be exposed to temperatures greater than 140 degrees F.

Property	Requirement (Note 1)			Test Method
	Supported Silt Fence (Note 2)	Unsupported Silt Fence		
		Woven	Non-Woven	
		Elongation <50% (Note 3)	Elongation ≥50% (Note 3)	
Maximum post spacing: ft. (m)	4 (1.2)	6.5 (2)	4 (1.2)	-
Grab strength: lbs. (N) Machine Direction X-Machine Direction	 90 (400) 90 (400)	 124 (550) 101 (450)	 124 (550) 101 (450)	ASTM D 4632
Permittivity: sec^{-1}	0.05			ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 30 (0.60)			ASTM D 4751
Ultraviolet stability (retained strength): %	70% after 500 hours exposure			ASTM D 4355

Notes:
(1) All numeric values except apparent opening size (AOS) represent minimum average roll values (MARV) in the weaker principal direction. Values for AOS represent maximum average roll values.
(2) Silt fence support shall consist of 14-gauge steel wire with a mesh spacing of 6 inches (150 mm) by 6 inches (150 mm) or prefabricated polymeric mesh of equivalent strength.
(3) As measured in accordance with ASTM D 4632.

Comment [FC9]: Under the Silt Fence Section 1014-8 Note (2) under Requirement (note 1) table: It is better to specify a specific strength and test method than stating it must be "equivalent" to a dissimilar material in strength.
ASTM D 6461 is going to replace this same language for that silt fence specification. NY DOT had the same language in Note 2 and they switched it to the follow:
"maximum mesh spacing of 6"x6" or polymeric mesh with a minimum strength of 200 lbs/ft x 200 lbs/ft (per ASTM D 6637)" This allows for wire with the more common 14g 4x4 or 2x4 wire and a set strength and test method for the polymeric mesh. (Hanes)

1014-9 Drainage Fabric:

Drainage fabric shall meet the requirements specified below.

Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

Drainage fabric shall meet the following strength requirements:

Property	Requirement (Note 1) Class 2 Non-Woven Elongation ≥50% (Note 2)	Test Method
Grab strength: lbs. (N)	157 (700)	ASTM D 4632
Sewn seam strength: lbs. (N)	142 (630)	ASTM D 4632
Tear strength: lbs. (N)	56 (250)	ASTM D 4533
Puncture strength: lbs. (N)	309 (1375)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure	ASTM D 4355

Notes:
(1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction.
(2) As measured in accordance with ASTM D 4632.

Drainage fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.5	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 70 (0.22)	ASTM D 4751

Note:
(1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.

1014-10 Stabilization Fabric:

Stabilization fabric shall meet the requirements specified below.

Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

Stabilization fabric shall meet the following strength requirements:

Property	Requirement (Note 1)		Test Method
	Class 1 Woven	Class 1 Non-Woven	
	Elongation <50% (Note 2)	Elongation ≥50% (Note 2)	
Grab strength: lbs. (N)	315 (1400)	202 (900)	ASTM D 4632
Sewn seam strength: lbs. (N)	283 (1260)	182 (810)	ASTM D 4632
Tear strength: lbs. (N)	112 (500)	79 (350)	ASTM D 4533
Puncture strength: lbs. (N)	618 (2750)	433 (1925)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure		ASTM D 4355

Notes:
(1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction.
(2) As measured in accordance with ASTM D 4632.

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.05	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 40 (0.43)	ASTM D 4751

Note:
(1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.

Stabilization fabric shall also meet the following requirements:

Comment [FC10]: Consideration should be given to including Class 2 (Moderate) for Stabilization (Propex)

Comment [FC11]: AASHTO SOM TS-4e is balloting a new Class 1+ Higher Strength Subgrade Enhancement Geotextile. AZ DOT should include Class 1+ for Stabilization/Reinforcement (Mirafi)

GUIDELINES FOR THE USE OF GEOGRID FOR BASE REINFORCEMENT AND GEOTEXTILE SEPARATION FABRIC

INTRODUCTION

These guidelines have been developed primarily to aid pavement design engineers in the implementation of geosynthetics such as geogrids and geotextile fabrics in the pavement design process for flexible pavements using aggregate base course. The two applications are the use of geogrid for base reinforcement to increase the mean design R-Value in the pavement design process and the use of geotextile fabric to provide a separation between the aggregate base course and the underlying subgrade soil.

The basis of this guide is:

U Over 20 years of successful geogrid and geotextile use on Arizona highways.

U Federal Highway Administration (FHWA) guidance.

U Association of State Highway Transportation Officials (AASHTO) published design practices.

U California Department of Transportation Guidelines for Project Selection and Design - Aggregate Base Enhancement with Biaxial Geogrids for Flexible Pavements, October 20, 2012.

GEOGRID BASE REINFORCEMENT

Geogrid base reinforcement is accomplished by placing a layer of geogrid at the bottom of the aggregate base course or within the aggregate base course.

The use of geogrid below and/or within the base course has the following potential benefits: U Reduced structural number for the pavement section, which may provide immediate cost savings.

U Increased performance life and reliability of the pavement structure.

U Improved compaction and uniformity over soft or variable soils.

U Reduced hauling and heavy construction truck traffic on local roads due to relatively less materials required for removal or replacement or backfill.

U Ability to install the product in a wide range of weather conditions.

U Improved safety due to reduced construction time from reduced hauling and processing of subgrade or backfill materials.

Appropriate Applications of Geogrid Base Reinforcement

Geogrids are intended for use as base reinforcement for asphalt (flexible) pavements only. At this time, the design procedure provides no known benefit for using geogrids for base reinforcement under concrete (rigid) pavements.

Geogrids for base reinforcement have been typically used by ADOT when the mean R-Value for design is greater than or equal to 10 and less than 20. The use of geogrids over subgrade soils with R-Values

ranging from 6 to 20 results in a more significant contribution to pavement section reduction than for subgrades with higher R-Values greater than 20.
DRAFT (05/21/2015) DESIGN GUIDELINES FOR BASE REINFORCEMENT

Limitations of Geogrid Base Reinforcement

Geogrids for base reinforcement are generally not suitable for use when the subgrade has an R-Value of greater than 20. The structural enhancement contribution from the geogrid would be relatively small.

Geogrids for base reinforcement should not be utilized over subgrade stabilized with lime or cement. The stabilized subgrade will be relatively stiffer and the structural enhancement contribution for the geogrid would be relatively small.

Geogrids for base reinforcement are generally not recommended for use over non-stabilized subgrade soils with a mean design R-Value of less than 6. In those cases, removal and replacement, stabilization with lime or cement, or geosynthetic stabilization of the subgrade is recommended.

DESIGN PROCESS FOR GEOGRID BASE REINFORCEMENT

The evaluation of the suitability of geogrid for base reinforcement in the flexible pavement design should be performed in the following manner:

1. Perform a Standard ADOT Flexible Pavement Design
It is assumed that subgrade sampling for pavement design has been performed and a design mean RValue for design has been determined. The standard pavement design will provide recommended thicknesses for AC and ABC.

2. Perform an ADOT Flexible Pavement Design with Geogrid
Increase the mean design R-Value for the subgrade soil by 10 and determine the required structural number for the pavement section reinforced with geogrid. Determine the required AC and ABC thicknesses for the pavement design with geogrid.

3. Evaluate the Subgrade to Determine Need for a Separation Geotextile Fabric A subgrade separation fabric may be required along with the geogrid base reinforcement depending upon the gradation of the subgrade. To ensure performance, use separation geotextile fabric if the gradation of the subgrade is not available or cannot be practically obtained.

Fine materials from the subgrade can migrate upward into the aggregate base, leaving voids in the subgrade or contaminating the ABC which may result in settlement or subsequent pavement rutting. To control this, a separation geotextile fabric should be placed at the subgrade-aggregate base course interface (below the geogrid base reinforcement). To determine whether a separation geotextile is necessary, the gradation should be evaluated as shown in Table D-1.

Table D-1: Warrant for Separation Geotextile

Subgrade Gradation/Type	Separation Geotextile
>35% passing No. 200 Sieve	Warranted
≤35% passing No. 200 Sieve	Not Warranted

Comment [FC12]: Table D-1 defines limits for fines where a separation fabric should be used. The table lists >35% fines for using a separation fabric, and < 35% no separation fabric required. Work done some 45 years ago showed that 5-10% fines plugged the aggregate base, sometimes even as little as 2%. WeI think that the 35% figure is too large and AZ DOT should consider a range of 10-15% (NAGS)

4. Placement of Geogrid Base Reinforcement in the Pavement Section
The position of the geogrid in the pavement section is important to the performance of the geogrid base reinforcement. The following notes regarding placement of the geogrid in the pavement section should be followed:

a)The minimum ABC thickness for use of geogrid in the pavement section must be greater than or equal to 6 inches.

b) For ABC thicknesses in the range of 6 to 18 inches, the geogrid should be placed at the interface between the subgrade and ABC.

c) For ABC thicknesses greater than 18 inches, geogrid is not recommended.

Comment [FC13]: It is suggested that for some cases, a geogrid placed at the mid-height of an ABC may provide benefit, even for thick (18-inch) layers. (Tensar)

5. Construction Cost Analysis

A cost analysis should be performed to show the economic benefit of geogrid base reinforcement in the pavement design. The cost of utilizing geogrid base reinforcement to improve the mean design R-Value by 10 and thereby reducing the thickness of ABC and/or AC in the pavement design should be compared to a cost analysis performed on the original design. The construction cost analysis for the design including base reinforcement geogrid must also include the cost of separation geotextile fabric if required.

MATERIAL SPECIFICATIONS

Geogrid shall conform to Section 1014-3 Geogrid of the ADOT Standard Specifications.

Separation geotextile fabric shall conform to Section 1014-4 Separation Geotextile Fabric of the ADOT Standard Specifications.

CONSTRUCTION SPECIFICATIONS

Geosynthetics utilized for base reinforcement shall be placed as specified in Section 306 Geogrid Base Reinforcement and Section 208 Separation/Stabilization Geotextile Fabric of the ADOT Standard Specifications.

GUIDELINES FOR THE USE OF GEOGRID AND GEOTEXTILE FOR SUBGRADE STABILIZATION

INTRODUCTION

These guidelines have been developed primarily to aid pavement design and construction engineers in implementation of geosynthetics such as geogrids and geotextiles in the pavement design process or during construction when soft subgrade soils are expected or are encountered. Other alternatives for subgrade stabilization such as lime treatment, cement treatment, or replacement with stable or drier soils should also be considered.

In stabilization design, the goal is to determine the aggregate thickness required to stabilize the subgrade and provide an adequate roadbed or stable platform for construction expedience using unreinforced aggregate or after reinforcement of the aggregate with a geosynthetic. If geosynthetics are utilized, they are placed directly on the subgrade, prior to placement of the required thickness of aggregate for stabilization.

DESIGN METHOD

The following design method utilized was developed by Steward, Williamson, and Mohney (Steward et al. 1977) for the United States Forest Service (USFS) for unpaved roadways with some recommended modifications based on review of various design procedures. Geotextiles may be used for subgrade stabilization in the same manner as for unpaved roadways.

This unpaved roadway design procedure assumes 50 to 100 mm (2 to 4 inches) of rut, but less than 2 inches of rut is generally acceptable during construction. Once the stabilized lift is completed, construction proceeds utilizing the recommended pavement design. So subgrade stabilization is for expedience in construction, to allow the use of construction equipment on a soft or saturated subgrade with low cohesion. If the subgrade is hard, no stabilization would be necessary even if the R-Value was low. The cost effectiveness is determined by the lesser thickness of base course needed to stabilize the subgrade prior to placing the base course for structural support necessary as part of the AASHTO pavement design.

The design process for subgrade stabilization involves utilizing the geogrid or geotextile, or geogrid and geotextile, to reduce the required thickness of replacement ABC to stabilize the subgrade. The design process should allow less than 2 inches of rut at the top of the replacement ABC, which would be the finish subgrade elevation. Although the design process does not address movement due to pumping at the top of the replacement ABC, the design process should minimize the potential for pumping at subgrade elevation. For compaction of asphaltic concrete, this is more of a concern than rut depth, especially if the design ABC thickness for the pavement section is less than 12 inches.

For soft subgrade with a shear strength in the range of 250 to 1000 psf (1.74 to 6.94 psi), both subgrade stabilization and base reinforcement applications are mobilized. For this subgrade strength level, either a nonwoven geotextile and geogrid or woven stabilization geotextile are recommended, and the

Comment [FC14]: The design methodology proposed in the draft guide utilizes Stewart et al. (1977) as its basis. The Steward et al. methodology was an empirical approach developed exclusively for geotextiles and for large rut depths (2 to 4 inches). Since neither limitation fits the stated objectives of the design guide, the Giroud-Han (2004) methodology is suggested for inclusion in the draft guide. This design approach, which is both theoretically-based and empirically calibrated, takes into account the distribution of stresses, strength of the base course material, geogrid-aggregate interlock, and geogrid in-plane stiffness, in addition to loading conditions. Importantly, use of the Giroud-Han (2004) methodology can incorporate a wide variety of geogrid types, once those types have been properly calibrated. (Tensar)

aggregate thickness for subgrade stabilization can be reduced using the appropriate reinforced bearing capacity factor in the design procedure.

For subgrade with a shear strength in the range of 1000 to 1500 psf (6.94 to 10.42 psi), the use of a nonwoven geotextile for separation is generally recommended for fine-grained subgrades. A nonwoven geotextile should also be used for separation when the designer has experienced separation problems with the construction materials during construction. It is recommended that the designer use bearing capacity factors for the inclusion of geogrid, nonwoven geotextile, woven geotextile and geogrid with nonwoven geotextile as provided in the design procedure. The aggregate thickness for subgrade stabilization can be reduced using the appropriate reinforced bearing capacity factor in the design procedure.

Stabilization is not normally required for subgrade with a shear strength of over 1500

psf (10.42 psi). The step by step design procedure is as follows:

1. Determine the subgrade soil strength. The subgrade shear strength, c, in psi is directly measured by a portable field vane shear test (ASTM D 2573), or may be determined by correlation with a field CBR (ASTM D 4429)or dynamic cone penetrometer (DCP) cone index test (ASTM D 6951). Figure 1 allows conversion from CBR (%) or cone index (mm/blow) to shear strength (c) in psi.
2. Make the strength determinations at several locations where the subgrade soils appear weakest. Strength should be evaluated over the depth range of 0 to 9 inches and 9 to 18 inches, taking six to 10 measurements at each location to obtain a good average value.
3. Determine the bearing capacity factors to be used according to Table 1:

Table 1. Stabilization Alternative vs. Bearing Capacity Factor (US ACE 2003)

Stabilization Alternative	**Bearing Capacity Factor, N_c**
Unreinforced Aggregate	2.8
Aggregate with Geogrid	5.8
Aggregate with Woven Geotextile	5.0
Aggregate with Nonwoven Geotextile	3.6
Aggregate with Geogrid and Nonwoven Geotextile	5.8

4. Determine the values of cN_c by multiplying the average c values by the applicable bearing capacity factor, N_c. Enter the values for cN_c into the graphs in Figures 2 and 3 to determine the required aggregate thicknesses for unreinforced aggregate, aggregate with geogrid, aggregate with woven geotextile, or aggregate with nonwoven geotextile.
5. Select the required aggregate thickness for each alternative to the next higher 1 inch.
6. Perform an economic analysis of each alternative to determine which is most cost effective. This may be accomplished using historical cost data for aggregate in place, geogrid installed, woven or nonwoven geotextile installed, and geogrid with nonwoven geotextile installed.
7. If a reinforced aggregate alternative is chosen, specify the geosynthetic material to be utilized. The material specifications for geogrid, woven geotextile, and nonwoven geotextile are in the ADOT Standard Specifications for Roadway and Bridge Construction as described in the next section.

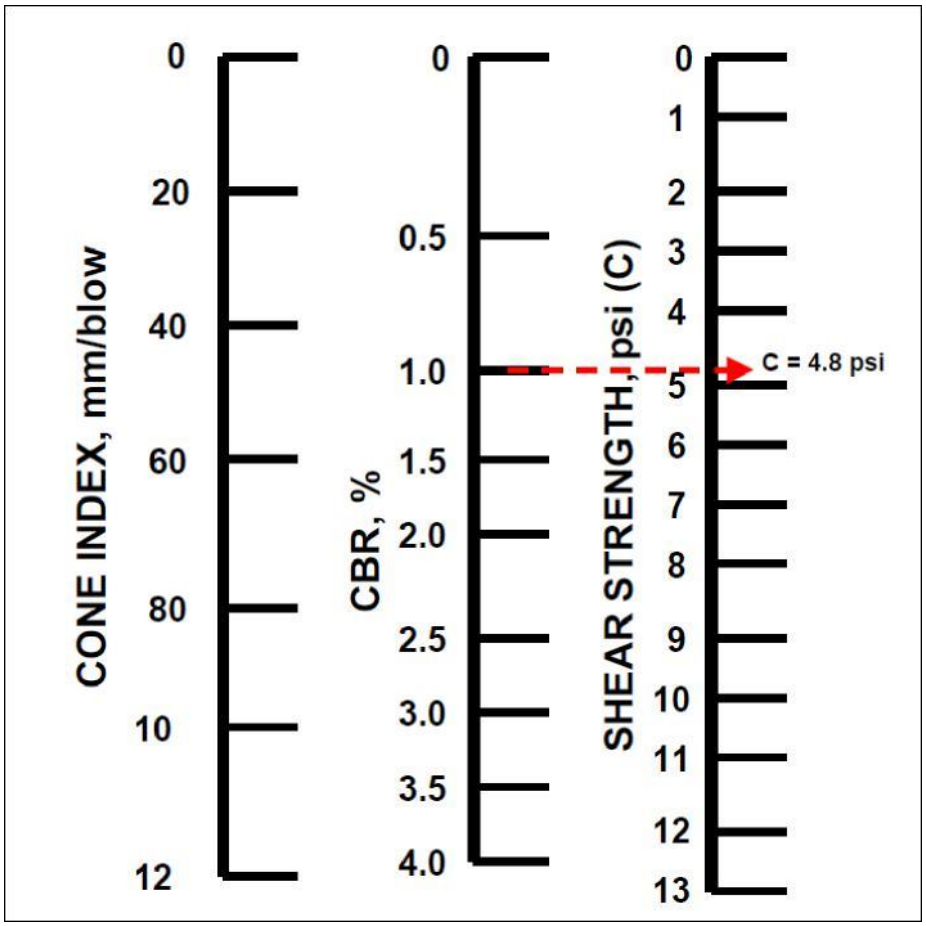

Figure 1. Relationship between cone index, CBR, and shear strength (c) (TM 5-518-8) (US Department of the Army 1995)

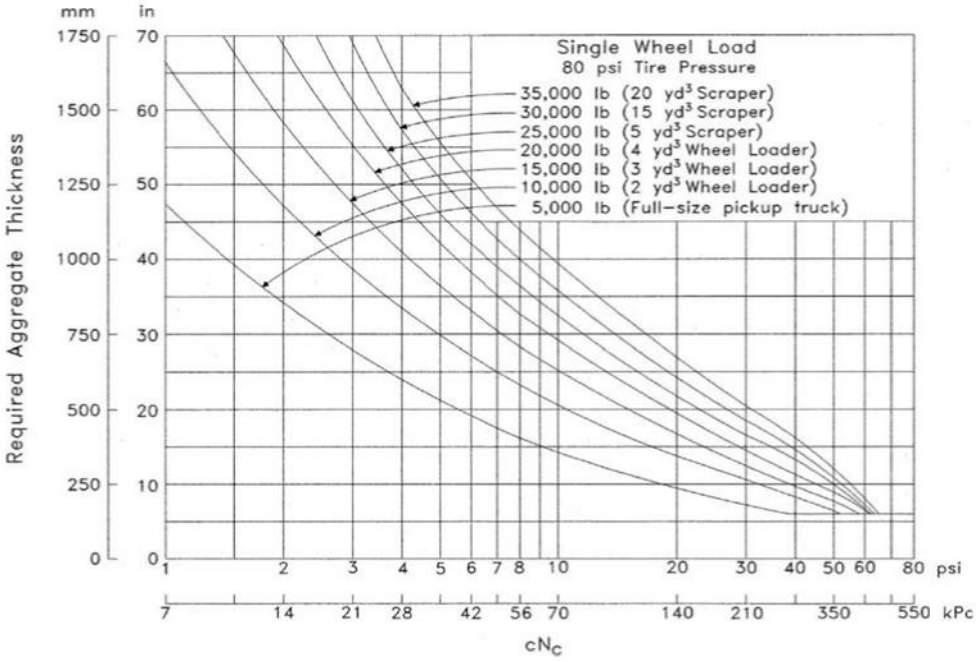

Figure 2. Aggregate Thickness – Single Wheel Load (Steward et al. 1977)

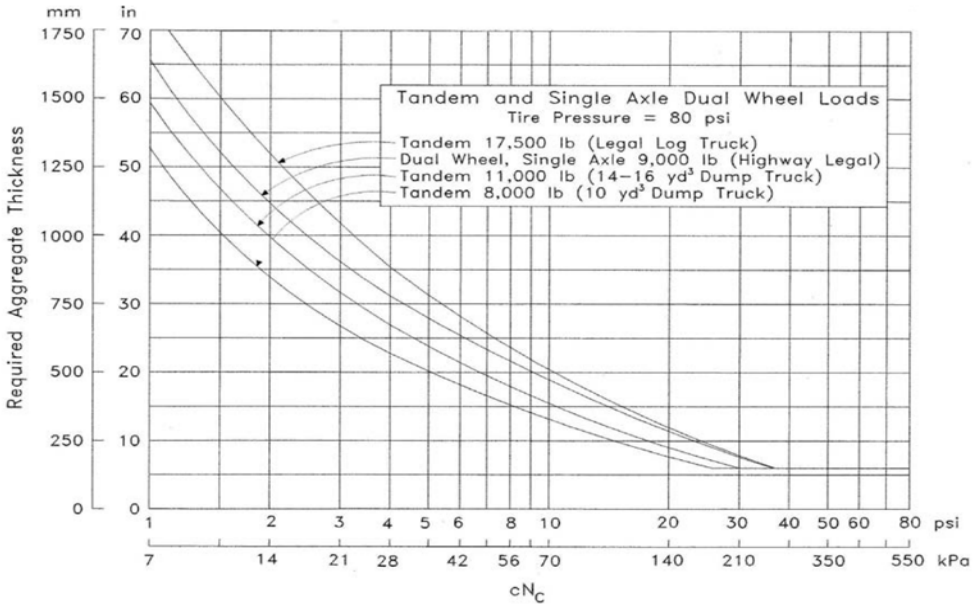

Figure 3. Aggregate Thickness – Tandem and Single Axle DualWheel Loads (Steward et al. 1977)

MATERIAL SPECIFICATIONS

Aggregate shall conform to Class 2 of Table 303-1 of the ADOT Standard Specifications.

Geogrid shall conform to Section 1014-3 Geogrid of the ADOT Standard Specifications.

Woven geotextile shall conform to Section 1014-10 Stabilization Fabric of the ADOT Standard Specifications.

Nonwoven geotextile shall conform to Section 1014-10 Stabilization Fabric of the ADOT Standard Specifications.

When geotextile is used together with geogrid in a subgrade stabilization application, the geotextile shall conform to Section 1014-4.02 Moderate Survivability Fabric of the ADOT Standard Specifications.

CONSTRUCTION SPECIFICATIONS

Geosynthetics utilized for subgrade stabilization shall be placed as specified in Section 306 Geogrid Base Reinforcement and Section 208 Separation/Stabilization Geotextile Fabric of the ADOT Standard Specifications.

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APPENDIX U: REVISED DRAFT SECTION 1014 GEOSYNTHETICS SPECIFICATIONS

(Proposed Standard Specifications)
November 9, 2015

SECTION 1014 GEOSYNTHETICS: of the Standard Specifications is revised to read:

1014-1 General Requirements:

Certificates of Compliance, conforming to the requirements of Subsection 106.05, shall be submitted to the Engineer by the contractor upon delivery of geosynthetic materials for use on a specific project. If the delivered materials have not been evaluated and preapproved as noted below, it will be necessary for a Certificate of Analysis to be submitted to the Engineer along with the supporting documentation before the material may be considered for use on the project. Each geosynthetic material lot or shipment must be approved by the Engineer before the materials may be incorporated in the work.

Certificates of Analysis, conforming to the requirements of Subsection 106.05, may be submitted, along with a representative sample of appropriate size for testing, by the supplier or manufacturer of any geosynthetic material to ADOT Materials Group for evaluation and preapproval. Testing methods and results shown in the Certificate of Analysis shall conform to the listed specifications for the proposed geosynthetic use. Supporting documentation including, but not limited to, product information sheets, installation procedures and recommendations, recommended use, and project references shall also be submitted by the supplier or manufacturer as part of product evaluation and preapproval.

Geosynthetic materials shall be furnished in protective covers capable of protecting the materials from harmful environmental conditions such as ultraviolet rays, abrasion, extreme heat, and water. Storage of the materials will be in a manner to prevent damage, contamination, or deterioration of the materials.

Samples of geosynthetic materials shall be submitted for testing. No samples shall be taken within five feet of either end of a roll. Samples shall be a minimum of six feet long by the full roll width. A minimum of one sample shall be taken per lot. More samples may be required as determined by the Engineer.

Requirements for pavement fabric, separation geotextile fabric, bank protection fabric, temporary silt fence fabric, drainage fabric, and stabilization fabric are generally in accordance with AASHTO M288.

1014-2 Pavement Fabric:

Pavement fabric shall meet the requirements specified below.

Fibers, yarns, and filaments used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

The pavement fabric shall be resistant to chemical attack, rot, and mildew, and shall have no tears or defects which will adversely alter its physical properties. The fabric shall be specifically designed for the designated pavement application, as a stress relieving membrane between two successive asphalt layers.

The width of the fabric shall be appropriate for the proposed construction.

Property	**Requirement (Note 1)**	**Test Method**
Mass per unit area: oz./sq. yd. (g/m^2)	4.0 (140)	ASTM D 5261
Grab strength: lb. (N)	100 (450)	ASTM D 4632
Ultimate elongation: %	≥50	ASTM D 4632
Melting point: degrees F (degrees C)	300 (150)	ASTM D 276
Asphalt Retention: gal./sq. yd. (L/m^2)	**(Notes 2 and 3)**	ASTM D 6140
Notes: (1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction. (2) Asphalt required to saturate paving fabric only. Asphalt retention must be provided in manufacturer certification. Value does not indicate the asphalt application rate required for construction. (3) Product asphalt retention property must meet the MARV value provided by the manufacturer certification.		

1014-3 Geogrid:

Geogrid reinforcement material for roadway base applications shall be a biaxial polymer grid structure, specifically fabricated for use as a base reinforcement. The width of the geogrid shall normally be approximately 13 feet or as appropriate for the proposed construction. The geogrid shall be one of the following structure types:

(A) A structure comprised of punched and drawn polypropylene sheet to form a grid.

(B) A structure comprised of polypropylene extruded to form a grid.

(C) A structure comprised of polypropylene integrally formed by extruding then stretching longitudinally and transversely to form a grid.

(D) A structure comprised of polypropylene bonded or welded to form a grid.

The geogrid material shall additionally conform to the following physical requirements:

Property	**Requirement**	**Test Method**
Average Aperture Size: inch (mm) MD, **(Note 2)** XD, **(Note 3)**	 0.8 - 1.4 (20 - 35) 0.8 - 1.4 (20 - 35)	I.D. Calipered, **(Note 1)**
Tensile Strength: lb./ft. (N/m) At 2% Strain At 5% Strain At 15% Strain	 400 (542) min. 800 (1084) min. 1300 (1762) min.	 ASTM D 6637
Junction Efficiency: %	93 min.	ASTM D 7737
Ultraviolet Stability: %	100 min.	ASTM D 4355
Notes: (1) Maximum inside dimension in each principal direction measured by calipers. (2) MD-Machine direction which is along roll length. (3) XD-Cross machine direction which is across the roll width.		

1014-4 Separation Geotextile Fabric:

Separation fabric shall meet the requirements specified below.

Fibers, yarns, and filaments used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

The fabric shall be inert to commonly encountered chemicals, resistant to rot and mildew, and shall have no tears or defects which adversely affect or alter its physical properties. The physical requirements for the separation fabric will be determined by the survivability rating called out for the fabric in the Special Provisions or as shown on the project plans. Requirements for each survivability rating are listed in Subsections 1014-4.01, 1014-4.02, and 1014-4.03.

1014-4.01 Low Survivability Fabric:

Low survivability fabric shall meet the following strength requirements:

Property	Requirement (Note 1)		Test Method
	Class 3 Woven	Class 3 Non-Woven	
	Elongation <50% (Note 2)	Elongation ≥50% (Note 2)	
Grab strength: lb. (N)	180 (800)	112 (500)	ASTM D 4632
Sewn seam strength: lb. (N)	162 (720)	101 (450)	ASTM D 4632
Tear strength: lb. (N)	67 (300)	40 (180)	ASTM D 4533
Puncture strength: lb. (N)	371 (1650)	223 (990)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure		ASTM D 4355
Notes: (1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction. (2) As measured in accordance with ASTM D 4632.			

Low survivability fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.07	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 70 (0.22)	ASTM D 4751
Note: (1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.		

1014-4.02 Moderate Survivability Fabric:

Moderate survivability fabric shall meet the following strength requirements:

Property	Requirement (Note 1)		Test Method
	Class 2 Woven	**Class 2 Non-Woven**	
	Elongation <50% (Note 2)	**Elongation ≥50% (Note 2)**	
Grab strength: lb. (N)	247 (1100)	157 (700)	ASTM D 4632
Sewn seam strength: lb. (N)	223 (990)	142 (630)	ASTM D 4632
Tear strength: lb. (N)	90 (400) **(Note 3)**	56 (250)	ASTM D 4533
Puncture strength: lb. (N)	495 (2200)	309 (1375)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure		ASTM D 4355

Notes:
(1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction.
(2) As measured in accordance with ASTM D 4632.
(3) The required MARV tear strength for woven monofilament geotextiles is 56 lb. (250 N).

Moderate survivability fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.07	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 70 (0.22)	ASTM D 4751

Note:
(1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.

1014-4.03 High Survivability Fabric:

High survivability fabric shall meet the following strength requirements:

Property	Requirement (Note 1)		Test Method
	Class 1 Woven	Class 1 Non-Woven	
	Elongation <50% (Note 2)	Elongation ≥50% (Note 2)	
Grab strength: lb. (N)	315 (1400)	202 (900)	ASTM D 4632
Sewn seam strength: lb. (N)	283 (1260)	182 (810)	ASTM D 4632
Tear strength: lb. (N)	112 (500)	79 (350)	ASTM D 4533
Puncture strength: lb. (N)	618 (2750)	433 (1925)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure		ASTM D 4355
Notes: (1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction. (2) As measured in accordance with ASTM D 4632.			

High survivability fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.07	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 70 (0.22)	ASTM D 4751
Note: (1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.		

1014-5 Bank Protection Fabric:

Bank protection fabric shall meet the requirements specified below.

Fibers, yarns, and filaments used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

The fabric shall be inert to commonly encountered chemicals, resistant to rot and mildew, and shall have no tears or defects which adversely affect or alter its physical properties.

Bank protection fabric shall meet the following strength requirements:

Property	**Requirement (Note 1)** **Class 1 Non-Woven** **Elongation ≥50% (Note 2)**	**Test Method**
Grab strength: lb. (N)	202 (900)	ASTM D 4632
Sewn seam strength: lb. (N)	182 (810)	ASTM D 4632
Tear strength: lb. (N)	79 (350)	ASTM D 4533
Puncture strength: lb. (N)	433 (1925)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure	ASTM D 4355
Notes: (1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction. (2) As measured in accordance with ASTM D 4632.		

Bank protection fabric shall also meet the following requirements:

Property	**Requirement (Note 1)**	**Test Method**
Permittivity: sec^{-1}	0.7	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 70 (0.22)	ASTM D 4751
Note: (1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.		

1014-6 Geocomposite Wall Drain System:

The Geocomposite Wall Drain System shall be of composite construction, consisting of a supporting structure of drainage core material and a geotextile filter fabric permanently bonded to the core material on one side only. The geocomposite shall be resistant to commonly encountered chemicals and hydrocarbons, and resistant to ultraviolet exposure.

1014-6.01 Geocomposite Wall Drain Core:

The wall drain core material shall consist of a preformed, stable, polymer plastic material with a cuspated, nippled, or geonet structure. The drainage core shall provide support for and shall be bonded to the geotextile filter fabric at intervals not exceeding 1-1/8 inches in any direction. Its preformed structure shall be perforated to allow water to flow freely to the weephole drainage outlets. If not perforated during manufacture, the core shall be perforated in the field at the weephole drainage outlet locations. The core shall have at least 14 square inches per square foot of flat area in contact with the geotextile fabric to support the fabric. The core material shall additionally conform to the following physical requirements:

Property	Requirement (Note 1)	Test Method
Thickness with fabric: inch (mm)	0.23 (5.8)	ASTM D 1777
Compressive Strength: psf (kN/m^2)	6,000 (287)	ASTM D 1621
Transmissivity; Gradient = 1.0, Normal Stress = 5000 psf (239 kN/m^2) gal./min./ft. (L/min./m)	4.0 (4.6)	ASTM D 4716
Note: (1) All numeric values represent minimum values.		

The geocomposite core shall be furnished with an approved method for connecting with outlet pipes or weepholes as shown on the plans. These fittings shall allow entry of water from the core, but shall not allow intrusion of backfill material into the core.

1014-6.02 Geocomposite Wall Drain Fabric:

The geotextile wall drain fabric shall be laminated onto or adhere to the side of the drainage core which will face the backfill. Geotextile wall drain fabric shall meet the requirements of Subsection 1014-9.

A minimum three-inch wide flap of geotextile fabric shall extend beyond both longitudinal edges of the geocomposite core. The geotextile fabric shall cover the full length of the core.

1014-7 Geocomposite Edge Drain System:

The Geocomposite Edge Drain System shall be of composite construction, consisting of a supporting rectangular structure of drainage core material wrapped with a geotextile filter fabric. The fabric shall surround and be attached to the core material in a manner which does not restrict the flow capacity of the core material. The geocomposite shall be resistant to commonly encountered chemicals and hydrocarbons, and resistant to ultraviolet exposure.

1014-7.01 Geocomposite Edge Drain Core:

The edge drain core material shall consist of a preformed, stable, polymer plastic material with a cuspated, nippled, ridged, slotted, and/or perforated structure. The drainage core shall provide support for and may be bonded to the geotextile filter fabric. Its preformed structure shall be perforated to allow water to flow freely to the weephole drainage outlets. If not perforated during manufacture, the core shall be perforated in the field at the weephole drainage outlet locations unless otherwise approved by the Engineer. The core shall have at least 14 square inches of flat area in contact with the geotextile fabric to support the fabric per square foot. The core material shall additionally conform to the following physical requirements:

Property	**Requirement (Note 1)**	**Test Method**
Thickness Wrapped with Fabric: inch (mm)	0.75 (19)	ASTM D 1777
Compressive Strength: psf (kN/m^2)	6,000 (287)	ASTM D 1621
Transmissivity; Fabric Wrapped Core, Gradient = 0.1, Normal Stress = 1440 psf (68.9 kN/m^2), gal./min./ft. (L/min./m)	4.0 (4.6)	ASTM D 4716, **(Note 2)**
Width: ft. (m)	1.0 (0.30) **(Note 3)**	Measured

Notes:
(1) All values represent minimum values.
(2) Use a full width panel, if possible, testing flow on the side which may be placed against the soil to be drained.
(3) Minimum width normally required, but shall be the minimum width specified on the plans, if that is greater.

1014-7.02 Geocomposite Edge Drain Fabric:

The geotextile edge drain fabric shall completely wrap around the drainage core material in a snug manner and may be permanently bonded to the core. Geotextile edge drain fabric shall meet the requirements of Subsection 1014-9.

1014-7.03 Outlet Pipes:

The pipe for the edge drain outlet lateral shall be rigid, four-inch diameter, Schedule 40 PVC pipe conforming to the requirements of ASTM D 1785, Schedule 40 polyethylene pipe conforming to the requirements of ASTM D 2104, or Schedule 40 ABS pipe conforming to the requirements of ASTM D 1527.

The open end of the outlet pipe conduit shall be connected into either a drainage structure or a concrete pad drain in accordance with the details shown on the plans.

1014-8 Temporary Silt Fence Fabric:

Temporary silt fence fabric shall meet the requirements specified below.

Fibers, yarns, and filaments used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

The fabric shall contain a stabilizer and/or inhibitors to make the filaments resistant to deterioration resulting from exposure to sunlight or heat.

The edges of the fabric shall be finished to prevent the outer yarn from pulling away from the fabric. The fabric shall be free of defects or flaws which significantly affect its physical or filtering properties. The fabric shall have a minimum width of 36 inches. Sheets of fabric may be sewn or bonded together. No deviation from any physical requirements will be permitted due to the presence of the seam.

The fabric may be manufactured with pockets for posts, hems with cord or with posts preattached using staples or button head nails.

During all periods of shipment and storage, the fabric shall be wrapped in a heavy duty protective covering which will protect the cloth from sunlight, mud, dust, and debris. The fabric shall not be exposed to temperatures greater than 160 degrees F.

Property	Requirement (Note 1)			Test Method
	Supported Silt Fence (Note 2)	Unsupported Silt Fence		
		Woven	Non-Woven	
		Elongation <50% (Note 3)	Elongation ≥50% (Note 3)	
Maximum post spacing: ft. (m)	4 (1.2)	6.5 (2)	4 (1.2)	-
Grab strength: lb. (N) Machine Direction X-Machine Direction	 90 (400) 90 (400)	 124 (550) 101 (450)	 124 (550) 101 (450)	ASTM D 4632
Permittivity: sec^{-1}	0.05			ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 30 (0.60)			ASTM D 4751
Ultraviolet stability (retained strength): %	70% after 500 hours exposure			ASTM D 4355

Notes:

(1) All numeric values except apparent opening size (AOS) represent minimum average roll values (MARV) in the weaker principal direction. Values for AOS represent maximum average roll values.

(2) Silt fence support shall consist of 14-gauge steel wire with a maximum mesh spacing of 6 inches (150 mm) by 6 inches (150 mm) or prefabricated polymeric mesh with a minimum strength of 200 lb./ft. (2,916 N/m) x 200 lb./ft. (2,916 N/m) per ASTM D 6637.

(3) As measured in accordance with ASTM D 4632.

1014-9 Drainage Fabric:

Drainage fabric shall meet the requirements specified below.

Fibers, yarns, and filaments used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

Drainage fabric shall meet the following strength requirements:

Property	**Requirement (Note 1)** **Class 2 Non-Woven** **Elongation ≥50% (Note 2)**	**Test Method**
Grab strength: lb. (N)	157 (700)	ASTM D 4632
Sewn seam strength: lb. (N)	142 (630)	ASTM D 4632
Tear strength: lb. (N)	56 (250)	ASTM D 4533
Puncture strength: lb. (N)	309 (1375)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure	ASTM D 4355
Notes: (1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction. (2) As measured in accordance with ASTM D 4632.		

Drainage fabric shall also meet the following requirements:

Property	**Requirement (Note 1)**	**Test Method**
Permittivity: sec^{-1}	0.5	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 70 (0.22)	ASTM D 4751
Note: (1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.		

1014-10 Stabilization Fabric:

Stabilization fabric shall meet the requirements specified below.

Fibers, yarns, and filaments used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed at least 95 percent, by weight, of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

Stabilization fabric shall meet the following strength requirements:

Property	Requirement (Note 1)		Test Method
	Class 1 Woven	Class 1 Non-Woven	
	Elongation <50% (Note 2)	Elongation ≥50% (Note 2)	
Grab strength: lb. (N)	315 (1400)	202 (900)	ASTM D 4632
Sewn seam strength: lb. (N)	283 (1260)	182 (810)	ASTM D 4632
Tear strength: lb. (N)	112 (500)	79 (350)	ASTM D 4533
Puncture strength: lb. (N)	618 (2750)	433 (1925)	ASTM D 6241
Ultraviolet stability (retained strength): %	50% after 500 hours exposure		ASTM D 4355
Notes: (1) All numeric values represent minimum average roll values (MARV) in the weaker principal direction. (2) As measured in accordance with ASTM D 4632.			

Stabilization fabric shall also meet the following requirements:

Property	Requirement (Note 1)	Test Method
Permittivity: sec^{-1}	0.05	ASTM D 4491
Apparent opening size: U.S. Standard sieve size (mm)	No. 40 (0.43)	ASTM D 4751
Note: (1) Values for permittivity represent minimum average roll values (MARV). Values for apparent opening size (AOS) represent maximum average roll values.		

APPENDIX V: DRAFT SPECIFICATION FOR TRIAXIAL GEOGRID OR ALTERNATE GEOGRID MATERIALS

DRAFT SPECIFICATION FOR TRIAXIAL OR ALTERNATIVE GEOGRID MATERIALS

The following specification could be added to Subsection 1014-3 to allow for the use of triaxial geogrid or other alternative geogrid materials.

1014-3.01 Alternative Geogrid Materials:

Alternative geogrid materials may be considered for a specific project based on documented performance, however, it is recommended that such material be approved in writing by the Engineer at least 15 days prior to bid date. In order to help the Engineer determine the appropriateness of alternative geogrid products, it is suggested that the product manufacturers include within their submittal packages the following information:

1. Full scale laboratory testing and in-ground testing of roadbed structures stabilized with the specific geogrid which quantifies the structural contribution of the geogrid to the roadbed structure in accordance with AASHTO Designation: R50-09. The performance benefit of the alternative geogrid must meet or exceed that of the geogrid originally specified.

2. A list of five comparable projects, in terms of size and application where the results of the specific alternative geogrid used can be verified after a minimum of 1 year of service life.

APPENDIX W: RECOMMENDED UPDATES TO STORED SPECIFICATION 208GEOM

Changes to the Stored Specification 208GEOM are recommended as shown. The specification should be renamed Composite Geomembrane because a composite of fabric and geomembrane are necessary to meet the strength, puncture, burst, and tear requirements. The specification should be incorporated into the Standard Specifications only if its use becomes more normal.

(208GEOM, 12/03/91)

ITEM 2080031 - Composite Geomembrane:

(1) Description:

The work under this item includes furnishing labor, equipment, and materials to construct a moisture barrier as detailed in the project plans and these Special Provisions. It also includes trench excavation, placement of the membrane, backfill and compaction. The purpose of the moisture barrier installation will be to restrict water infiltration from the roadway ditches and roadway prism to the underlying soils.

(2) Material Requirements:

~~The geomembrane moisture barrier shall conform with the general requirements listed in Subsection 1014-1 of the Standard Specifications.~~

~~The moisture barrier shall consist of one of the following options:~~

~~(a) An impervious sheet (or film geomembrane) of single-layered construction, without seams.~~

~~(b) A fabric-reinforced geomembrane, of composite construction that adheres to one of the following options:~~

~~1) Polyethylene film or sheet bonded to the fabric.~~

~~2) Polyethylene film or sheet laminated between two fabrics.~~

~~3) Fabric laminated inside the polyethylene sheet.~~

The moisture barrier shall consist of an impervious fabric-reinforced geomembrane, of composite construction that adheres to one of the following options:

(a) Polyethylene film or sheet bonded to the fabric.

(b) Polyethylene film or sheet laminated between two fabrics.

(c) Fabric laminated inside the polyethylene sheet.

The geomembrane shall be inert to chemicals and hydrocarbons and shall be resistant to mildew, rot, ultraviolet exposure, insects and rodents. It shall also conform to the minimum average roll values for properties listed in the following table:

Property	Requirements	Test Method
~~Width: ft.~~	~~9~~	~~N.A.~~
~~Thickness: mils~~	~~14~~	~~ASTM D 1777~~
~~Grab Tensile Strength; at break or 100% elongation, whichever occurs first: lbs.~~	~~170~~	~~ASTM D 4632~~
~~Grab Elongation at Break: %~~	~~20~~	~~ASTM D 4632~~
Tensile (1-inch strip), lb/ft (kN/m)	754 (11)	ASTM D 882
Breaking Elongation: %	20	ASTM D 822
Puncture Strength: lb. (N)	494 (2400)	ASTM D ~~4833~~ 6241
~~Burst Strength: psi~~	~~250~~	~~ASTM D 3786~~
~~Trapezoidal~~ Tear Strength: lb. (N)	90 (400)	ASTM D 4533
~~Permittivity: second $^{-1}$~~	~~0 Max.~~	~~ASTM D 4491~~
Ultraviolet Stability (Retained Strength): %	50 after 500 hours exposure	ASTM D 4355

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D 4354 and tested according to the test method specified above.

Samples of the geomembrane shall be submitted for testing. No samples shall be taken within five feet of either end of a roll. Samples shall be a minimum of three feet long by the full roll width. A minimum of one sample shall be taken per lot. More samples may be required as determined by the Engineer.

The contractor shall submit a sample of the proposed geomembrane, selected on the basis of material property requirements previously listed, prior to use. If the sample fails, the contractor may submit another sample of geomembrane product for testing. A maximum of three geomembrane products will be evaluated and tested by ADOT. Each submittal shall include product information sheets and Certificate of Analysis as required by Subsection 1014-1 of the Standard Specifications.

(3) Construction Requirements:

The geomembrane shall be installed in accordance with the plans, these Special Provisions, and the manufacturer's installation procedures and recommendations.

Weather Limitations:

Geomembrane shall not be placed when weather conditions, in the opinion of the Engineer, are not suitable to allow placement or installation. This will normally be at times of wet or

snowy conditions, heavy rainfall, extreme cold or frost conditions, ~~or~~ extreme heat, or excessively windy conditions.

Equipment:

Mechanical or manual laydown equipment shall be capable of handling full rolls of fabric, and laying the fabric smoothly, without wrinkles and folds, in the position specified. The equipment shall be in accordance with the manufacturer's recommendations or as approved by the Engineer.

Subgrade Preparation:

~~The subgrade shall be prepared in accordance with Subsection 203-3.03(A) of the Standard Specifications, prior to placement of the geomembrane.~~ The surface upon which the geomembrane will be placed shall be prepared by clearing, grubbing, and excavation or filling the area to the design grade. This includes removal of topsoil and vegetation in accordance with Section 201. The surface shall be compacted and finished according to Subsection 205-3.04 or as approved by the Engineer. Soft spots and unsuitable areas will be identified during the subgrade preparation or subsequent proof rolling. These areas shall be excavated and backfilled with select material as approved by the Engineer and compacted in accordance with the requirements of Subsection 205-3.04

Geomembrane Placement:

The installation of the geomembrane shall be in accordance with the following sequence:

(A) In areas requiring geomembrane placement in a vertical trench, trenches will first be excavated to the minimum dimensions listed in the plans details. Geomembrane material shall be placed against the inside wall of the excavated trench, extending the full depth of the trench and a minimum of 24 inches onto the horizontal subgrade surface. Bonded geomembrane with fabric on only one side shall be placed with the fabric side toward the outside or backfill side of the trench. Geomembrane which extends onto the horizontal subgrade surface shall be fixed to the subgrade surface with stakes, nails or other method approved by the Engineer to secure the geomembrane in place during backfilling of the trench. Immediately following the geomembrane placement, the vertical trench shall be backfilled with cement-treated slurry conforming to Section 501-3.02 of the Standard Specifications to within one foot of subgrade elevation. No backfilling above the cement-treated slurry shall be commenced until 24 hours after its placement. The final one foot of the trench shall be backfilled with excavated clay material, after it is processed to $\pm$ three percent of optimum moisture content. This clay backfill shall be compacted to 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer. Extreme care shall be taken in avoiding damage to the geomembrane supported on the trench wall. Removal and replacement of any geomembrane that is damaged will be the responsibility of the contractor.

(B) Geomembrane shall then be placed over the horizontal subgrade surface to the extent shown on the plans details. All wrinkles and folds shall be removed and overlaps shall be a minimum 24 inches wide. Any geomembrane which extends onto the subgrade from a vertical trench shall also be overlapped a minimum of 24 inches, with the horizontal subgrade geomembrane overlapped over the geomembrane from the vertical trench. Bonded geomembrane with fabric on only side shall be placed with the fabric side upward. Sewn seams will not be permitted unless it can be demonstrated that they are watertight factory seams. The placement of the geomembrane by dragging across the finished surface will not be allowed.

On curves, the geomembrane may be folded or cut to conform to the curves. The fold or overlap shall be in the direction of construction and held in place by piles of fill or rock.

Prior to being covered, the geomembrane shall be inspected to ensure that the geomembrane has not been damaged (i.e. holes, tears, rips) during installation. The inspection shall be done by the Engineer or designated representative. Damaged geomembrane, as identified by the Engineer, shall be repaired immediately. Cover the damaged area with a geomembrane patch that extends an amount equal to three feet on all sides beyond the damaged area.

Placement and Compaction of Aggregate:

Aggregate materials shall be placed by back dumping the aggregate in a manner which does not damage the geomembrane. The aggregate material shall be spread in a minimum thickness of eight inches onto the geomembrane in a constant forward direction. Traffic or construction equipment shall not be permitted directly on the geomembrane unless approved by the Engineer for emergency purposes. Pins or piles of aggregate can be used to hold the geomembrane in place while being covered.

Overstressing the subgrade soil shall be avoided by utilizing equipment in spreading and dumping that exerts only moderate pressures on the soil. If ruts of two inches or greater occur in the aggregate, the contractor shall use lighter equipment which transmit less ground pressure. Any ruts which develop during spreading or compacting aggregate shall be filled with additional aggregate rather than bladed from adjacent areas so that the final design aggregate thickness is maintained. Construction equipment shall not be allowed to turn or stop suddenly on the aggregate placed over the geomembrane. Aggregate base shall be compacted as specified in Subsection 303-3.02. Aggregate base material shall not be mixed or processed on the geomembrane. The aggregate base material shall be premixed at the stockpile area or at another location in a manner approved by the Engineer. Aggregate base materials will be sampled for acceptance after premixing and prior to placement on the geomembrane. Contamination and segregation of aggregate base materials prior to or during placement shall be minimized.

Any damage to the geomembrane occurring during placement of the aggregate shall be repaired immediately. The aggregate shall be removed from the damaged area to allow placement of a geomembrane patch extending three feet on all sides beyond the damaged area, followed by replacement of the aggregate.

(4) Method of Measurement:

The geomembrane shall be measured for payment by the square yard, complete in place. No additional measurement or allowance will be made for material in overlaps or seams.

(5) Basis of Payment:

The accepted quantities of geomembrane, measured as provided above, will be paid for at the contract unit price, which shall include full compensation for furnishing all labor, equipment, and materials involved in placement of the geomembrane as shown in the project plans. No measurement or payment will be made for geomembrane that has been damaged.