ODOT SPECIAL PROVISIONS FOR HIGH-STRENGTH GEOTEXTILES AND GEOGRIDS: PHASE I - TENSILE STRENGTH PROPERTIES OF HIGH-STRENGTH GEOTEXTILES FOR HIGHWAY REINFORCEMENT AND STABILIZATION APPLICATIONS

FINAL REPORT

ODOT TASK ORDER NUMBER 2160-21-07

Submitted to:

Office of Research and Implementation
Oklahoma Department of Transportation

Submitted by:

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OKLAHOMA Transportation

July 2021

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)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		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)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		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)

EXECUTIVE SUMMARY

This study is aimed to develop a set of special provisions for enhancement geotextiles and high-strength geogrids for ODOT roadway projects. Such special provisions are currently not available, and as a result, the department does not have a consistent method to compare enhancement geotextile products for their acceptance and use in different projects it currently sponsors.

This first phase of the study focused on identifying a selection of suitable enhancement geotextile products for roadway projects that included currently-used and potentially comparable products relative to their tensile strength and hydraulic properties. A list of candidate products and their properties relative to the corresponding requirements in AASHTO M288-2017 and several state DOTs are provided and discussed.

In collaboration with the Materials Division and Field District 4, initial plans have been made to carry out field studies that would help produce first-hand data for ODOT to evaluate the comparative performance of different enhancement products side-by-side in conjuction with the subgrade, climatic and traffic conditions that are most relevant and specific to the state. This will help ODOT develop reliable and cost-effective specifications for enhancement geotextile products for consideration and approval in different roadway projects.

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1. Introduction

This study was carried out in response to a task order request by Mr. Matt Romero, PE, which is aimed to develop a set of special provisions for enhancement geotextiles and high-strength geogrids for ODOT roadway projects. Such special provisions are currently not available, and as a result, the department does not have a consistent method to compare high-strength reinforcement products for their acceptance and use in different projects it currently sponsors.

This first phase of the study focused on identifying a selection of suitable enhancement geotextile products for roadway reinforcement that included the currently-used, TenCate Mirafi RS380*i* and RS580*i* and other products with comparable tensile strength and hydraulic properties. This task was accomplished through collection and survey of test data on related material properties from different sources, and communications with different ODOT field districts and contractors.

This report also includes these entities' field experience with the enhancement geotextile products currently used in ODOT projects. During the course of this study, we also worked with the Materials Division and Field District 4 on initial plans for field testing and verification of a shortlist of geotextile products to help develop a reliable set of specifications for enhancement geotextiles for ODOT projects. Descriptions of different activities, and discussions of the results are presented separately in the following sections.

2. Identification of enhancement geotextile products

Enhancement geotextiles are a newer category of products (Designated as Class 1A) with tensile strength and permittivity values that are greater than those in Class 1 category (i.e. the highest survivability class), with required properties as given in Table 6 of the AASHTO M288-17 specifications (**Figure 1**). The enhancement specification is applicable to the use of geotextiles in pavement structures on weak subgrades (i.e. CBR

≤ 1, or shear strength ≤ 30 kPa), and typically in saturated or nearly saturated conditions. In such applications, the enhancement geotextile provides several simultaneous functions that include separation, filtration and reinforcement, among others.

Standard Specification for

Geosynthetic Specification for Highway Applications

AASHTO Designation: M 288-17

Technical Subcommittee: 4e, Joints, Bearings, and Geosynthetics

Release: Group 2 (June)

Table 6—Enhancement Geotextile Property Requirements

	Test Methods	Units	Requirements
Geotextile class			Class 1A from Table 1[a]
Wide width tensile	ASTM D4595	kN/m	70
Sewn seam strength	ASTM D4884/D4884M	kN/m	42
Permittivity	ASTM D4491	sec^{-1}	0.2[a]
Apparent opening size	ASTM D4751	mm	0.60 max avg roll value
Ultraviolet stability (retained strength)	ASTM D4355/D4355M	%	70% after 500 h of exposure

[a] Default value. Permittivity of the geotextile should be greater than that of the soil ($\Psi g > \Psi s$). The engineer may also require the permeability of the geotextile to be greater than that of the soil ($kg > ks$).

Figure 1. Enhancement Geotextile Property Requirements per the applicable ASTM test protocol (AASHTO 2017)

The objective of this task was to identify a select group of enhancement geotextile products suitable for reinforcement and moisture control applications in ODOT projects. At the start of this project, we had in-person meetings and follow-up communications with the Materials Division engineers, Messrs. Matt Romero, PE, Scott Garland, PE and Kenny Seward, PE, through which we gathered information on the current status of product recommendation and use relative to high-strength geotextiles in ODOT roadway projects. We learned that TenCate Mirafi RS380*i* and RS580*i* were the predominant products that were specified in different roadway projects. Meanwhile, products from other suppliers had also been submitted for consideration as comparable products at lower costs. Therefore, through further communications with different contractors and field districts, and a review of different product datasheets from manufacturers we gathered test data on Mirafi RS380*i* and RS580*i* and several alternative products for comparison purposes as shown in **Table 1**. This table also includes other products that have been submitted for consideration for use in ODOT roadway projects, and additional products which may also be considered comparable to the Mirafi products upon further examination and verification. Additinally, specifications of several other state departments of transportation on enhancement geotextile products were surveyed, and the results are summarized in **Table 2**.

3. Tensile strength tests and comparison with AASHTO M288 requirements

The initial intent in this study was to carry out laboratory tensile strength tests on samples of the identified products (**Table 1**) in their as-delivered conditions from field projects. To this end, we reached out to several contractors and field districts and requested samples of the above materials for testing. However, despite several follow-up communications, we learned that no extra samples had been kept from previous jobs, and new samples from any ongoing or upcoming projects might take a while to become available for shipment to our labs.

Table 1. Comparison of selected enhancement geotextile products for roadway reinforcement applications

Product	Grab (lbs)		Strain %		Trapezoidal (lbs)		Puncture (lbs)	Wide-width (lbs/ft)			
								2% strain[2]		Ultimate[2,3]	
	MD	XD	MD	XD	MD	XD		MD	XD	MD	XD
Mirafi RS380*i*[1,4]	686	463	20	16	186	232	2,172	600	1,020	NR, >1,800	NR, >2,256
Mirafi RS580*i*	NR	NR	NR	NR	NR	NR	NR	480	1,800	NR, >1,440	NR, >4,380
Mirafi H_2R*i*	NR	NR	NR	NR	NR	NR	NR	480	1,080	5,280	5,280
Winfab 400HTM[4]	478.8	585.6	32	62	230	320	2,078	600	1,020	NR, >1,800	NR, >2,256
Winfab 600HTM[4]	621.9	1187.7	23	23	240.1	778.5	2,255	480	1,800	NR, >1,440	NR, >4,380
Winfab 777102[4]	655.1	480.5	22	16	175.3	263.8	2,108	NA	NA	NA	NA
Winfab 9172SPR[4]	634.8	1,165.6	23	24	248.4	620.9	2,285	NA	NA	NA	NA
TerraTex HPG-HM38[2]	522	389	15	9	164	188	2,064	600 1,292[5]	1,020 1,917[5]	4,977[5] @10.7%	4,559[5] @6.4%
TerraTex HPG-HM58[5]	700 775[1]	521 605[1]	17 23[1]	10 11[1]	221 273[1]	259 225[1]	2,613 2,330[1]	1,112	2,267	6,113 @11.4%	5,589 @6.2%
TerraTex HPG-70[2]	NR	NR	NR	NR	NR	NR	NR	NR	NR	4,800	4,800
TerraTex HPG-700[2]	700	700	20	15	250	250	1,700	NR	NR	6,056	5,515

[1] NTPEP (unless stated otherwise); MD (Machine Direction), XD (Cross-Machine Direction), During production

[2] PDS: Product Datasheet (unless stated otherwise)
NR: Not Reported in PDS; NA: Not Available

[3] When NR, strength at 5% strain is reported here

[4] Source for Grab, Trapezoidal and Puncture strength values: email communications with Mr. Jamie Malmstrom

[5] Determined using TRI (2018) data

Table 2. Required property values for enhancement geotextile products in roadway applications as available in selected state DOTs

DOT	Approved Product	Grab (lbs)		Strain %		Trapezoidal (lbs)		Puncture (lbs)	Wide-width (lbs/ft)						AOS[1]	ψ[2] (s^{-1})
									2% strain		5% strain		Ultimate			
		MD	XD	MD	XD	MD	XD		MD	XD	MD	XD	MD	XD		
AK	Type 2 - HP570, Propex 4X4HF, WinFab 4800/30, H_2Ri	400	400	10	10	150	150	1,500			2,400	2,400	4,800	4,800	30	0.2
GA[3]	H_2Ri (Inundated area only)										1,440	3,780	5,280	5,280		
KS	H_2Ri															
MN	Type 13, Class 1A in AASHTO M288			20	20											0.4
MO	H_2Ri							2,300	540	900	1,620	3,900	5,400	5,400	40	0.24
MT	HS + Wick[4]								480	1,080			5,280	5,280	40	0.4
NM	Type 1 - RS380i								600	1,020	1,800	2,256			40	0.9
	Type 2 - RS580i								480	1,800	1,440	4,380			40	1.0
TX	RS580i															
UT	Type 1 - RS380i								600	1,020	1,800	2,256			40	0.9
	Type 2 - RS580i								480	1,800	1,440	4,380			40	1.0

Notes: Strength properties listed in the table are MARV values; Products without manufacturer's name refer to TenCate Mirafi;
[1] Apparent Opening Size (US Sieve No.); [2] Permittivity; [3] "Allow to Use"; [4] High-strength woven geotextile with wicking capability

Therefore, we proceeded to obtain tensile strength and other material properties of these products from alternative sources. These sources included product technical datasheets from the suppliers and detailed lab data from NTPEP and third-party laboratories. During in-person meetings and communications with Mr. Matt Romero, PE, we determined that the product information we have gathered through these sources are adequate for this stage of the project.

Nevertheless, we also proceeded with a series of preliminatry tensile strength tests on a polypropylene woven geotextile sample we had available in our laboratory, in preparation for any future need for index testing of select geosynthetic products. Example results are presented in **Figure 3**, which indicate that the test setup and procedure, and the product itself yield consistent test performance. The ultimate tensile strength of this product is determined as 3,250 lbs./ft at 26% strain in machine direction (MD), which qualifies it as a Class 2 product based on the AASHTO M288 specifications for survivability requirements. In contrast, the products we have identified for future field trials (See **Section 4**) are designated as Class 1A for enhancement application with the corresponding strength and permittivity requirements.

AASHTO M288-17 requirements for geotextiles with enhanced mechanical properties in roadway reinforcement applications call for a wide-width tensile strength value of 70 kN/m (equivalent to 4,800 lbs/ft) using the ASTM D4595 test protocol (**Figure 1**). It is interesting to note that, this is the same ultimate strength value recommended for geotextile reinforcement in GRS bridge abutments (Adams and Nicks 2018). Tensile strength properties of the products identified in this study as possible candidates for enhancement geotextiles for ODOT projects are provided in **Table 1**. The data show that the unltimate wide-width tensile strength values for those products reported in the table meet or exceed this requirement. Nevertheless, the actual field performance of these products needs further investigation, which is the subject of a subsequent study as

breifly described in **Section 4** of this report. Additionally, the following observations are made based on the test results and PDS values in **Table 1** on the products that are under consideration for field trials:

1. No puncture strength requirements are currently listed for Class 1A (i.e. enhancement) products in AASHTO M288-17 specifications. Nevertheless, puncture strength values of all products in the table are significantly greater than the Class 1 (i.e. high survivability) requirements for woven geotextiles. Therefore, the candidate products shortlisted for field trials are expected to sustain minimal damage during installation or service. Nevertheless, actual installation damage tests need to be carried out on these products to determine their design reduction factors, in parallel with their field investigation, for inclusion in ODOT special provisions.

TerraTex HPG-HM38

High Performance Geotextile

TerraTex HPG-HM38 is a polypropylene woven geotextile with high tenacity yarns. This engineered geotextile is also stabilized to resist degradation due to ultraviolet exposure, commonly encountered soil chemicals, mildew and insects; it is also non-biodegradable. TerraTex HPG-HM38 is manufactured to meet the following minimum average roll values:

Property	Test Method	Minimum Average Roll Values English	Minimum Average Roll Values Metric
Wide Width Tensile (2% Strain XMD)	ASTM D-4595	1,020 lbs/ft	14.9 kN/m
Wide Width Tensile (2% Strain MD)	ASTM D-4595	600 lbs/ft	8.8 kN/m
Wide Width Tensile (5% Strain XMD)	ASTM D-4595	2,256 lbs/ft	32.9 kN/m
Wide Width Tensile (5% Strain MD)	ASTM D-4595	1,800 lbs/ft	26.3 kN/m
Permittivity	ASTM D-4491	0.9 sec^{-1}	0.9 sec^{-1}
Water Flow Rate	ASTM D-4491	75 $gal/min/ft^2$	3056 $L/min/m^2$
AOS (Maximum Average Roll Value)	ASTM D-4751	40 US Std. Sieve	0.425 mm
Factory Seam Strength	ASTM D-4884	2,700 lbs/ft	39.4 kN/m
UV Resistance	ASTM D-4355	90% @ 500 hrs	90% @ 500 hrs

Roll Property	Typical English	Typical Metric
Roll Dimensions (width x length)	15 x 300 ft	4.6x 91.5 m
Roll Area	500 yd^2	418 m^2

1/2018

(a)

Quote ID:	QUO-18969-P9T6		Rev: 1
Bid Date:	9/19/2019	Hanes Project:	PRJ-0012711
REPLY TO:			
Contact:	Eva Majors		
Title:	Inside Sales Rep		
Phone:	405-470-6965		
Fax:	405-470-6943		
E-mail:	eva.majors@hanescompanies.com		

Hanes Geo Components Project Quote

www.hanesgeo.com

Heavy Civil & Erosion Control Contractors choose Hanes Geo Components as their trusted partner to provide first quality stabilization fabrics, geogrids and stormwater compliance products at a honest price.

Project Name:	OKDOT McClain County NHPPI-0035(297)SS	Project Id:	Call Order #800
Company:	**Oklahoma Bidder**		
Attn:		Phone:	
E-mail:		Fax:	

"The following estimated quantities are provided for informational purposes only; the contractor is responsible for determination of the material quantities used in preparation of the bid"

CONFIDENTIAL MATERIAL QUOTATION - 30 DAY PRICE GUARANTEE

Product	Product Description	Comment	Quantity	Unit Price	UOM	Unit Total
79299	3605-FLA48-D	221(C) 2801 TEMPORARY SILT FENCE	2,358	$0.2100	LF	$495.18
38194	TERRATEX N16 15'X150' 250 SY	317 4270 CEMENT TREATED BASE	1,252	$1.4000	SY	$1,752.80
38499	TERRATEX HPG-HM38 15'X300' 500 SY	326(A) 0100 GEOTEXTILE REINFORCEMENT	22,635	$1.8500	SY	$41,874.75
38136	TERRATEX OLI 12.5'X360' 500 SY	409(A) 4242 FABRIC REINFORCEMENT	1,052	$0.4000	SY	$420.80
81789	TRIANGULAR SILT DIKE 10"X7'	TEMPORARY SILT DIKE	14	$28.0000	EA	$392.00

Subtotal	$44,935.53
+ Estimated Freight	$0.00
Estimated Project Total	$44,935.53

Footnotes:
Full Roll Quantities Only
PO must be received and materials shipped within 30 days of contract award to hold pricing
Delivery fee applicable for less than truckload quantities

(b)

Figure 2. Example data on an enhancement geotextile product (i.e. Terratex HPG-HM38 supplied by Hanes Geo) that has been submitted as equivalent to TenCate Mirafi RS380*i*: (a) Product datasheet and (b) Price quotation

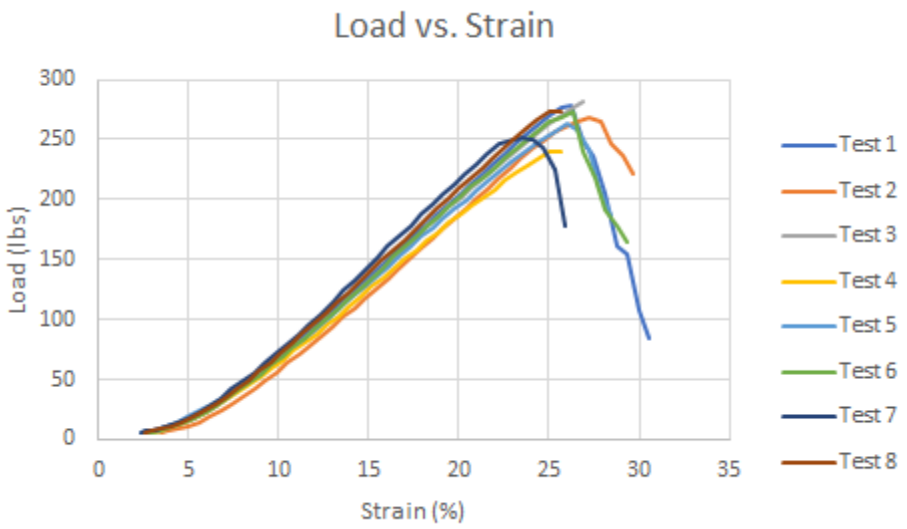


Figure 3. Example test results on a woven polypropylene geotextile reinforcement

2. The wide-width tensile strength properties of these products from third-party lab results in both the MD and XD are greater than the posted values in the product datasheet. Additionally, the XD values at low strain (i.e. 2% or 5%) are signifcantly greater than those in MD, which is to be expected because these products are typically placed along the roadway in MD, and therefore, need to provide better confinement and resist greater stresses in the transverse direction. For instance, the wide-width tensile strength values at 5% strain for the TerraTex HPG-HM38 product in MD and XD (not included in the table) are 2,735 lbs/ft and 3,962 lbs/ft, respectively (TRI 2018). The corresponding values reported on the PDS are 1,800 lbs/ft and 2,256 lbs/ft, respectively. In comparison, the wide-width tensile strength values at 5% strain for the heavier HPG-HM58 product in MD and XD are 2,811 lbs/ft and 4,949 lbs/ft, respectively. Greater tensile strength and stiffness at low strains provide greater lateral confinement to the base coarse aggregates, which provides enhanced properties such as a greater M_R Improvement Factor and Traffic Benefit Ratio (TBR) among other benefits (e.g. Tingle and Webster 2003, AASHTO R50-09, Luo et al. 2017). However, the unltimate wide-width tensile strength values of both

HPG-HM38 and HPG-HM58 product in XD are smaller than in MD due to rupture at lower strains (**Table 1**). This indicates that the production technique for these products has resulted in higher low-strain tensile strength at the cost of reduced ductility, which warrants further examination in cases where rutting and larger deformations could be expected during service conditions (e.g. unpaved roads, saturated subgrade, etc.).

3. Relative to hydraulic properties of the products listed in **Table 1** (available in the TRI 2018 report):
    a. AOS = 0.4 mm (#40) for these products (e.g. HPG-HM38 and HPG-HM58), which satisfies the rquirements for enhancement, stabilization and separation applications in the AASHTO M288-17 specifications.
    b. Permittivity of these products well exceeds the mimimum requirements for enhancement application. For instance, test values for the permittivity of HPG-HM38 and HPG-HM58, per ASTM D4491 are reported as 1.2 and 0.97 s^{-1}, respectively. The corresponding PDS values for both the HPG-HM38 and RS380*i* (as comparable products) are 0.9 s^{-1}. The PDS value for H_2R*i* is 0.4 s^{-1}. All these values satisfy the AASHTO M288-17 minimum requirement for enhancement geotextile products of 0.2 s^{-1}. The *permeability* values for HPG-HM38 and HPG-HM58 are practically the same and equal to 0.12 cm/s.

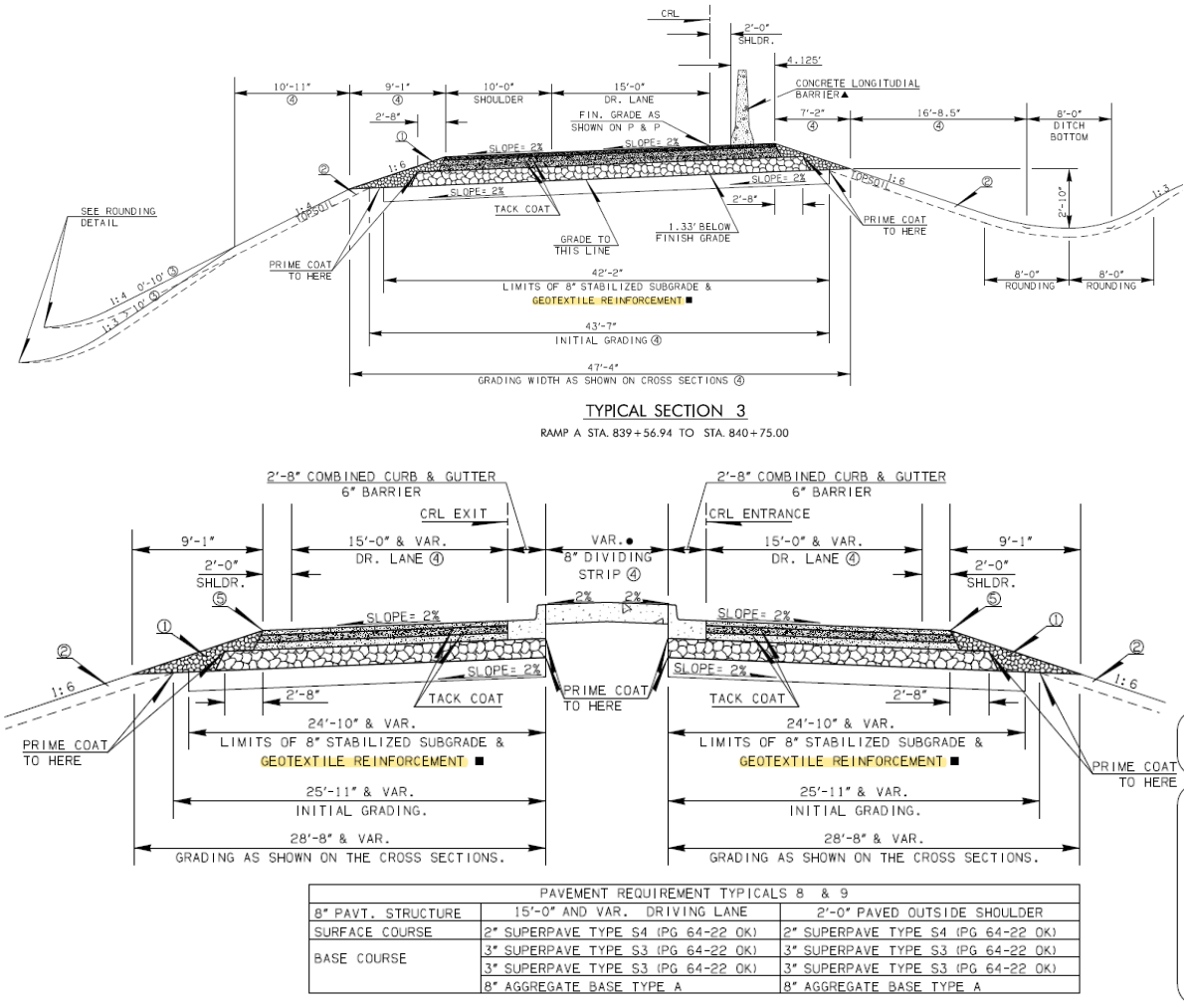
4. Field districts' and contractors' experience

We reached out to several ODOT field districts and contractors about their field experience with enhancement geotextiles. These parties included ODOT Field Districts Nos. 1, 3, 4 and 7 and a few contractors, including Sherwood Construction, Koss Construction and Allen Contracting. We learned that field applications of enhancement geotextiles in different ODOT roadway projects have essentially been limited to TenCate

Mirafi products. Accounts of field experience from several individuals are provided below:

From Mr. John Jackson, PE, with Allen Constracting:

"Allen Contracting, Inc. has one recent project that used heavyweight geotextile as part of the pavement section. The project is located at the interchange of SH-74 and I-35 in McClain County [**Figure 4**]. The project was designed by the ODOT and you can download the complete plan set from their website here: https://www.odot.org/contracts/a2019/plans1909/800_1909_NHPPI-0035(297)SS_2328304/000%20FULL%20FILE.pdf



PAVEMENT REQUIREMENT TYPICALS 8 & 9		
8" PAVT. STRUCTURE	15'-0" AND VAR. DRIVING LANE	2'-0" PAVED OUTSIDE SHOULDER
SURFACE COURSE	2" SUPERPAVE TYPE S4 (PG 64-22 OK)	2" SUPERPAVE TYPE S4 (PG 64-22 OK)
BASE COURSE	3" SUPERPAVE TYPE S3 (PG 64-22 OK)	3" SUPERPAVE TYPE S3 (PG 64-22 OK)
	3" SUPERPAVE TYPE S3 (PG 64-22 OK)	3" SUPERPAVE TYPE S3 (PG 64-22 OK)
	8" AGGREGATE BASE TYPE A	8" AGGREGATE BASE TYPE A

Figure 4. Typical roadway sections in the project at the interchange of SH-74 and I-35 in McClain County where enhancement geotextiles have been specified

The plans called for Mirafi RS380*i* or approved equal. Hanes Geo had quoted Terratex HPG-HM38 as a direct replacement at the time of bid (the quote is shown in **Figure 5**). After award of the contract Hanes Geo did not follow through with obtaining approval from Materials Div. for this product, so we were unable to use it and we were forced to purchase RS380*i* at a higher price from another vendor.

From what I have been told from the field, the Mirafi fabric performed very well. As I recall there were a couple of locations of unsuitable material in the existing roadbed of SH-74. Those areas were excavated and a layer of RS380*i* was installed at the bottom prior to placing new borrow material. These spots bridged the underlying soils very well and did not cause any problems in the subsequent base course installed over them."

PAY QUANTITIES

ROADWAY 100

ITEM		DESCRIPTION		UNIT	QUANTITY	
201(A)	0102	CLEARING AND GRUBBING		LSUM	1.00	
202(A)	0183	UNCLASSIFIED EXCAVATION	(R-1)(1)	CY	13,828.00	
202(D)	0184	UNCLASSIFIED BORROW	(R-3)	CY	7,017.00	
205(A)	4229	TYPE A-SALVAGED TOPSOIL	(R-4)(R-6)	LSUM	1.00	
210	0121	OBLITERATING ABANDONED ROAD	(2)	LF	769.00	
221(C)	2801	TEMPORARY SILT FENCE	(R-8)	LF	2,358.00	
221(K)	0600	TEMPORARY FIBER LOG	(R-8)	LF	98.00	
230(A)	2806	SOLID SLAB SODDING		SY	49,531.00	
230(F)	2812	WATERING	(R-9)	KGAL	1,982.00	
233(A)	2817	VEGETATIVE MULCHING	(R-11)	AC	10.23	
234(A)	2824	FERTILIZING (10-20-10)	(R-12)	TON	5.00	
241	2832	MOWING	(R-15)	AC	20.46	
303(A)	2100	AGGREGATE BASE TYPE A		CY	4,873.00	
307(K)	4300	STABILIZED SUBGRADE		SY	24,014.00	
317	4270	CEMENT TREATED BASE		SY	1,252.00	1
326(A)	0100	GEOTEXTILE REINFORCEMENT		SY	22,635.00	
402(E)	0225	TRAFFIC BOUND SURFACE COURSE TYPE E	(R-18)	TON	2,775.00	
407(B)	0250	TACK COAT	(3)	GAL	6,789.00	
408	5774	PRIME COAT	(R-21)	GAL	13,990.00	
409(A)	4242	FABRIC REINFORCEMENT		SY	1,052.00	
411(B)	5945	SUPERPAVE TYPE S3 (PG 64-22 OK)	(R-24)(8)	TON	8,339.00	4
411(C)	5950	SUPERPAVE TYPE S4 (PG 76-28 OK)	(R-24)(9)	TON	5,662.00	4
411(C)	5960	SUPERPAVE TYPE S4 (PG 64-22 OK)	(R-24)(4)	TON	3,228.00	
412	5267	COLD MILLING PAVEMENT	(R-26)	SY	6,396.00	
414(C)	4425	CONT. REINF. P.C.C. PAVEMENT (PLACEMENT)		SY	1,152.00	2

Figure 5. Quantities of enhancement geotextile that have been specified in the SH-74 and I-35 roadway project in McClain County

From Mr. Rick Howland, PE, Assistant District 4 Engineer:

"Here at ODOT we are just starting to use this material and specifically call out this product. I have personally used the RS-380*i* in two different locations due to poor soil conditions. One was off NW 178th and SH-74, on 178th Street due to the existing soil conditions. Even trying to stabilize the top 12" we were having issues with additional moisture in the soil and not getting any strength to place asphalt on. We decided to place a layer of RS380*i* with 12" of aggregate base and then 11" of asphalt.

The other project was up in Kay County on a County road project that CED8 was overseeing for ODOT. Had a similar issue where we had excessive moisture in the existing soil that went three plus feet deep in areas. I made the suggestion of installing the RS380i to bridge the areas and place a minimum of 8" of aggregate base before placing asphalt. I believe this county road only had 6 to 8 inches of asphalt placed on it."

From Mr. Jamie Malmstrom, PE, Assistant District 1 Engineer:

"A few contractors we've had install geotextile are: Koss construction, Sherwood, Duit. We have primarily only used the Mirafi products in district 1, I have reviewed the independent lab data of other products and found no approved equals to mirafi."

5. Summary and Conclusions

The objective of this study was to identify candidate enhancement geotextile products for possible inclusion in an ODOT special provisions for acceptance and use in roadway projects. A list of possible enhancement products, together with their material properties and related requirements in AASHTO M288-17 and in several state DOT specifications have been presented in this report. The above information and field

experience from different ODOT districts and contractors indicate that TenCate Mirafi RS380*i*, RS580*i* and H2R*i* are the predominant geotextile enhancement products specified and used in ODOT and other DOT projects. Meanwhile, there are several other products that may also be adequate for similar applications at lower costs, which need to be examined through field trials.

Previous studies have shown that differences in index properties of geosynthetic products do not necessarily result in the same level of difference in their field performance (e.g. Wang 2009, Hatami et al. 2011). Therefore, aside from the laboratory test data that have been gathered and compiled from different sources, a more reliable comparison of different products' suitability for roadway enhancement applications would need to include their actual field performance under subgrade, climatic and traffic conditions that are more specific to ODOT projects.

There have been several large-scale laboratory and accelerated field studies where the performances of unreinforced and geosynthetic-reinforced sections have been compared under simulated traffic load (e.g. Abu-Farsakh and Chen 2010, Cuelho et al. 2014, Luo et al. 2017). More recently, Roodi et al. (2018) carried out a series of field studies to examine the effectivness of geosynthetic reinforcement in preventing longitudinal cracks in pavements due to expansive subgrade soils. However, no such field studies have so far been carried out in Oklahoma. Additionaly, these studies primarily focused on comparing the field performances of geogrids, whereas the objective of this ODOT project at this stage is to help develop special provisions for enhancement geotextile products.

In communications with Messrs. Romero and January (Field District 4), we have already initiated plans to identify suitable ongoing projects within the greater Oklahoma City metro area for this purpose. In this regard, we have shortlisted the following products for possible field testing:

TenCate Mirafi RS380*i* and RS580*i*, which are specified and used more commonly by ODOT,

Mirafi H2R*i* woven geotextile with wicking properties for high water table/saturated soil conditions,

Hanes Geo TerraTex HPG-HM38, and HPG-HM58 (**Table 1**), which are identified by the supplier company as more economical alternatives to RS380*i* and RS580*i*, but with comparable properties, respectively, and

Winfab 400HTM and 600HTM, which have also been submitted to ODOT for consideration in recent projects as products comparable to RS380*i* and RS580*i*, respectively.

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