Report No UT.09-15

Constructability Evaluation of Two Geogrids at Tie Fork Rest Area on SR-6 in Region Three

Tenax MS™ 330 versus Tensar® BX 1200

Experimental Feature No. X(09)07

FINAL REPORT

Prepared for
Utah Department of Transportation,
Research Division

Submitted by:
Ken Berg, P.E., Development Engineer

Authored by:
Ken Berg, P.E., Development Engineer
Kelly Burns, Rotational Engineer

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George Lukes, UDOT Central Materials State Engineer

Steven Anderson, UDOT Central Materials, Pavement Design Engineer

Deryl Mayhew, UDOT Central Materials, Implementation Engineer

Matt Parker, UDOT Region 3, Resident Engineer

Kurtis Park, UDOT Region 3 Engineering Tech IV

Ken Berg, UDOT Research Division, Development Engineer

Barry Sharp, UDOT Research Division, Research Specialist

David Simmons, UDOT Region 3, Rotational Engineer

Tensar International Corporation

Tenax Corporation, USA

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16. Abstract Highly unstable subgrades often prompt the utilization of subgrade reinforcement as opposed to sub-excavation and granular fill. However, the performance measures necessary to ensure effective Geogrids have been, up until this point, somewhat undefined. This project presents the opportunity to compare the installations of two Geogrid projects in a side by side field test.		
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TABLE OF CONTENTS

1.0 Introduction 1
2.0 Research Method 2
3.0 Installation 2
4.0 Data 8
5.0 Conclusion 8

LIST OF FIGURES

Figure 1 Location Map 1
Figure 2 Installing the Mirafi® filter fabric, (looking east) 2
Figure 3 Installing the Tensar® BX1200 3
Figure 4 Installing the Tenax MS™ 330 3
Figure 5 Tenax MS™ 330 longitudinal overlap 3
Figure 6 Tensar® BX1200 longitudinal overlap 4
Figure 7 Transverse overlap at the middle of the section, Tenax MS™ 330 on the right, Tensar® BX1200 on the left 4
Figure 8 Shallower excavation near the highway 5
Figure 9 Building the haul road 5
Figure 10 Standing water, typical throughout test deck 6
Figure 11 Consolidating structural fill 6
Figure 12 Bench excavation being placed in the standing water 7
Figure 13 Pumping the free standing water 7

1.0 INTRODUCTION

In 2009 UDOT changed the alignment of SR-6 near milepost 203. The new highway alignment extends over the existing Tucker Rest Area. This rest area had been one of the most popular and busiest non-interstate rest areas in the State of Utah. A new rest area, Tie Fork Rest Area, 29 miles east of Spanish Fork, UT, is scheduled for future construction along Highway 6 at Milepost 202 (Fig. 1)

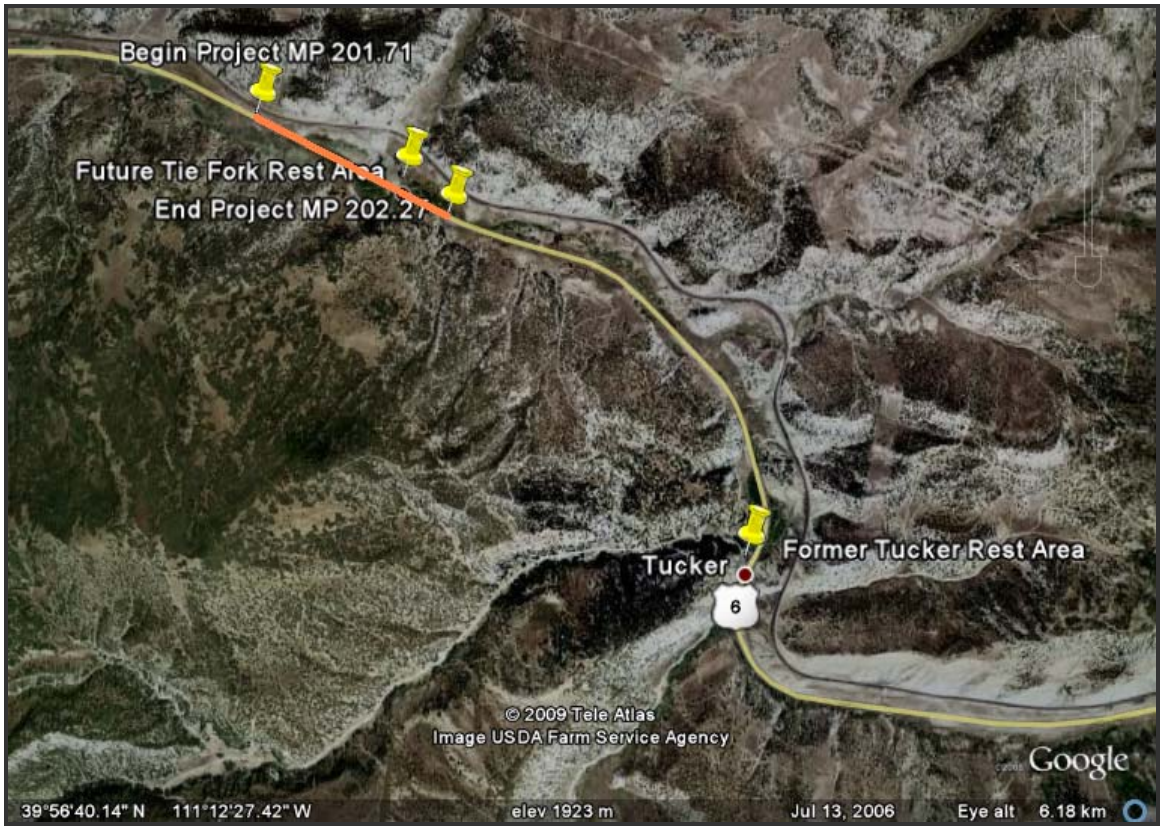

Figure 1 Location Map

In May 2009, UDOT contracted with Wardell Brothers Construction (Morgan, UT) to construct turn lanes to access the future Tie Fork Rest Area. As excavation began on the eastbound widening, the contractor experienced unstable soil conditions. Heavy clay soil, combined with a high water table, caused a Caterpillar D5XL dozer to sink to the top of its tracks. The decision was made by UDOT engineers to employ a biaxial geogrid material in an attempt to reinforce and stabilize the subgrade. UDOT recognized the opportunity to compare the constructability and performance of two types of geogrids in stabilizing subgrade during embankment construction. Tensar and Tenax, two geogrid manufacturers, were both invited to furnish an appropriately designed geogrid for installation and testing.

Brandon Reall of Tensar used a Deep Cone Penetrometer (DCP) to determine the California Bearing Ratio (CBR) value of the soil. Because of the soft soil subgrade the DCP did not function and Tensar had to assume CBR values of less than 1. Based on the

assumed CBR value and empirical observation of the soil conditions, Tenax provided the MS330 product (Appendix A) and Tensar provided the BX1200 product (Appendix B).

2.0 RESEARCH METHOD

The installation processes have been evaluated through interviews of UDOT construction crews and field observations made by UDOT Research personnel.

3.0 INSTALLATION

UDOT divided a 40 feet wide by 1100 feet long section of what would become the eastbound shoulder and embankment of the highway into two 550 feet long sections. To prevent fines from migrating into the two geogrids, a layer of Mirafi® N-series geotextile (Appendix C) was first applied as a filter fabric along the entire length of the section (Fig. 2).

Figure 2 Installing the Mirafi® filter fabric, (looking east)

Both materials were then placed by hand on the Mirafi® filter fabric. Tensar® BX1200 was installed on the western end (Figure 3) and Tenax MS™ MS330 was installed on the east end (Figure 4).

Figure 3 Installing the Tensar® BX1200

Figure 4 Installing the Tenax MS™ 330

The adjacent geogrid widths were longitudinally overlapped 3 feet in accordance with both manufacturers' recommendations. (Figures 5 and 6).

Figure 5 Tenax MS™ 330 longitudinal overlap

Figure 6 Tensar® BX1200 longitudinal overlap

At interface of the two products, in the middle of the test section, the products were also installed with a three foot overlap (Figure 7).

Figure 7 Transverse overlap at the middle of the section, Tenax MS™ 330 on the right, Tensar® BX1200 on the left

The excavation depth from finished grade ranged from about 6 feet deep at the outer edge of the planned embankment to about 3 feet deep adjacent to the existing highway. The shallower excavation nearer the highway was wide enough to create a bench that served as a haul road for importing the fill material (Figure 8 and Figure 9).

Figure 8 Shallower excavation near the highway

Figure 9 Building the haul road

Standing water was evenly visible along both sections (Figure 10).

Figure 10 Standing water, typical throughout test deck

The structural fill was specified to be non-plastic, well graded gravel passing a 75 mm (3 inch) sieve and retained on a 2 mm (#10 sieve). A Caterpillar 315C tracked excavator spread the granular borrow along the haul road in 6 foot wide strips. This created a working platform for the excavator to spread subsequent strips between the existing roadway and the planned edge of the embankment. The weight of the excavator was used to consolidate each lift by traveling back and forth over the entire area (Figure 11).

Figure 11 Consolidating structural fill

By the beginning of the second day of construction, the haul road displayed some deformation. To reduce the deformation, the Contractor sub excavated about 2-1/2 feet of the temporary roadway and replaced it with granular borrow. The contractor rebuilt the remaining haul road portion using a design similar to that of SR-6. Filter fabric combined with Geogrid was installed up to the edge of the existing highway cut and covered with 24 inches of structural fill. The bench was reshaped by removing up to 18 inches of excess soil. The excess soil was distributed evenly in the standing water with the track excavator rather than the traditional grader due to the small size and remote location of this project (Figure 12). However, the high ground water continuously pumped up through the grade so a small electric pump was used to remove as much of that water as possible (Figure 13).

Figure 12 Bench excavation being placed in the standing water

Figure 13 Pumping the free standing water

4.0 DATA

The research conducted on this project is limited to the evaluation of the installation processes and whether each product worked at stabilizing the subgrade enough to be able to be built upon with out delaying the project.

The UDOT project materials lab performed an AASHTO T180 Moisture/Density test on the embankment material, resulting in a target dry density of 138 lb/ft^3 and an optimum moisture content of 6.8% (Appendix D). Field density readings were taken with a Troxler nuclear gage but, because the subgrade was too rocky to test, the readings were inconsistent. Tensar and Tenax representatives have visited the project and have ensured their respective products were installed according to their recommendations.

UDOT Research personnel took field notes and pictures during the installation process. Later, comments were taken from UDOT Construction Crews regarding their impressions of the installation. The UDOT inspector on the project observed that both products performed similarly in stabilizing the subgrade during construction (Appendix E).

5.0 CONCLUSION

Both products seemed similar in performance and constructability

Neither product delayed the schedule by requiring more time to install than the other.

Although the Tenax product tended to deflect vertically more than the Tensar product as the first 12 inch lift was being built, as the grade came up during construction of second12 inch lift, both products seemed similar in performance.

Appendix A

product specifications

TENAX MS 330

TENAX MS™ 330 is composed of three layers of high strength extruded biaxial oriented polypropylene geogrids. The layers are rolled and stitched together without superimposing the grids creating a geogrid with random sized apertures designed to accommodate a variety of fill materials. The random aperture geometry, many tensile elements, and multiple layers of the geogrid enhance soil/geogrid interaction. TENAX MS™ 330 geogrid greatly improves the geogrid interlocking capacity, distributes applied loads, and prevents localized shear failure.

TYPICAL APPLICATIONS

Soft soil stabilization · Base reinforcement · Embankments over soft soils · Working platforms · Haul roads

MATERIAL CHARACTERISTICS	TEST METHOD	DATA
polymer type		polypropylene
carbon black content	ASTM D 4218	0.50%

DIMENSIONAL CHARACTERISTICS	TEST METHOD	UNIT		NOTES
thickness: rib - MD/TD	ASTM D 1777	in (mm) / in (mm)	0.05 (1.27) / 0.05 (1.27)	b,d,e
aperture size		in (mm) / in (mm)	1.65 (42) x 1.96 (50)	b,d,e
open area	CW 02215	%	70	b
roll dimensions		ft x ft (m x m)	13.1 x 164 (4.0 x 50)	b
roll area		yd² (m²)	239.2 (200)	b
gross roll weight		lb (kg)	163 (74)	b

TECHNICAL CHARACTERISTICS	TEST METHOD	UNIT			NOTES
Strengths & Load Capacity:			MD	TD	
peak tensile strength	ASTM D6637	lb/ft (kN/m)	1,370 (20.0)	2,100 (30.7)	a,c,e
tensile strength @2% strain	ASTM D6637	lb/ft (kN/m)	418 (6.1)	620 (9.0)	a,c,e
tensile strength @5% strain	ASTM D6637	lb/ft (kN/m)	925 (13.5)	1,343 (19.6)	a,c,e
initial modulus	ASTM D6637	lb/ft (kN/m)	27,420 (400)	44,550 (650)	a,c,e
tensile modulus @ 2% strain	ASTM D6637	lb/ft (kN/m)	20,900 (305)	30,800 (450)	a,c,e
tensile modulus @ 5% strain	ASTM D6637	lb/ft (kN/m)	18,500 (270)	26,852 (392)	a,c,e
Structural Integrity:					
junction: strength	GRI-GG2	lb/ft (kN/m)	1,274 (18.6)	1,970 (28.8)	a,e
efficiency		%	93		a,e
flexural rigidity	ASTM D 1388	mg-cm	750,000	750,000	b
Durability:					
resistance to installation damage	ASTM D 5818	%SC/%SW/%GP	>90/>90/90		

NOTES: a: Minimum average roll values determined in accordance with ASTM D4759; b: Typical values; c: Tests performed using extensometers; d: Single layer value; e: MD: machine direction (longitudinal to the roll), TD: transverse direction (across roll width)

TENAX® TENAX Corporation, Geosynthetics Division
4800 East Monument Street, Baltimore, MD 21205
1.800.356.8495 www.tenax.net
06/11/2008

Appendix B

Tensar International Corporation
5883 Glenridge Drive, Suite 200
Atlanta, Georgia 30328-5363
Phone: 800-TENSAR-1
www.tensar-international.com

Product Specification - Biaxial Geogrid BX1200

Tensar International Corporation reserves the right to change its product specifications at any time. It is the responsibility of the specifier and purchaser to ensure that product specifications used for design and procurement purposes are current and consistent with the products used in each instance.

Product Type: Integrally Formed Biaxial Geogrid
Polymer: Polypropylene
Load Transfer Mechanism: Positive Mechanical Interlock
Primary Applications: Spectra System (Base Reinforcement, Subgrade Improvement)

Product Properties

Index Properties	Units	MD Values[1]	XMD Values[1]
▪ Aperture Dimensions[2]	mm (in)	25 (1.0)	33 (1.3)
▪ Minimum Rib Thickness[2]	mm (in)	1.27 (0.05)	1.27 (0.05)
▪ Tensile Strength @ 2% Strain[3]	kN/m (lb/ft)	6.0 (410)	9.0 (620)
▪ Tensile Strength @ 5% Strain[3]	kN/m (lb/ft)	11.8 (810)	19.6 (1,340)
▪ Ultimate Tensile Strength[3]	kN/m (lb/ft)	19.2 (1,310)	28.8 (1,970)
Structural Integrity			
▪ Junction Efficiency[4]	%	93	
▪ Flexural Stiffness[5]	mg-cm	750,000	
▪ Aperture Stability[6]	m-N/deg	0.65	
Durability			
▪ Resistance to Installation Damage[7]	%SC / %SW / %GP	95 / 93 / 90	
▪ Resistance to Long Term Degradation[8]	%	100	
▪ Resistance to UV Degradation[9]	%	100	

Dimensions and Delivery

The biaxial geogrid shall be delivered to the jobsite in roll form with each roll individually identified and nominally measuring 3.0 meters (9.8 feet) or 4.0 meters (13.1 feet) in width and 50.0 meters (164 feet) in length. A typical truckload quantity is 160 to 210 rolls.

Notes

1. Unless indicated otherwise, values shown are minimum average roll values determined in accordance with ASTM D4759-02. Brief descriptions of test procedures are given in the following notes.
2. Nominal dimensions.
3. True resistance to elongation when initially subjected to a load determined in accordance with ASTM D6637-01 without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.
4. Load transfer capability determined in accordance with GRI-GG2-05 and expressed as a percentage of ultimate tensile strength.
5. Resistance to bending force determined in accordance with ASTM D5732-01, using specimens of width two ribs wide, with transverse ribs cut flush with exterior edges of longitudinal ribs (as a "ladder"), and of length sufficiently long to enable measurement of the overhang dimension. The overall Flexural Stiffness is calculated as the square root of the product of MD and XMD Flexural Stiffness values.
6. Resistance to in-plane rotational movement measured by applying a 20 kg-cm (2 m-N) moment to the central junction of a 9 inch x 9 inch specimen restrained at its perimeter in accordance with U.S. Army Corps of Engineers Methodology for measurement of Torsional Rigidity.
7. Resistance to loss of load capacity or structural integrity when subjected to mechanical installation stress in clayey sand (SC), well graded sand (SW), and crushed stone classified as poorly graded gravel (GP). The geogrid shall be sampled in accordance with ASTM D5818-06 and load capacity shall be determined in accordance with ASTM D6637-01.
8. Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments in accordance with EPA 9090 immersion testing.
9. Resistance to loss of load capacity or structural integrity when subjected to 500 hours of ultraviolet light and aggressive weathering in accordance with ASTM D4355-05.

Tensar International Corporation warrants that at the time of delivery the geogrid furnished hereunder shall conform to the specification stated herein. Any other warranty including merchantability and fitness for a particular purpose, are hereby excluded. If the geogrid does not meet the specifications on this page and Tensar is notified prior to installation, Tensar will replace the geogrid at no cost to the customer.

This product specification supersedes all prior specifications for the product described above and is not applicable to any products shipped prior to June 1, 2007

Appendix C

TENCATE
Mirafi®

Mirafi® N-Series Nonwoven Polypropylene Geotextiles
for Soil Separation and Drainage

Mirafi® N-Series Nonwoven Geotextiles

TenCate™ develops and produces materials that function to increase performance, reduce costs and deliver measurable results by working with our customers to provide advanced solutions.

The Difference Mirafi® N-Series Nonwoven Geotextiles Make:

- Construction. Mirafi® N-Series polypropylene nonwoven geotextiles easily conform to the ground or trench surface for trouble-free installation.
- Strength. Mirafi® N-Series geotextiles withstand installation stresses with high puncture and tear resistance.
- Drainage. High permittivity properties provide high water flow rates while providing excellent soil retention.
- Environmental. Mirafi® N-Series geotextiles are chemically stable in a wide range of aggressive environments.
- Cost Effective. Mirafi® N-Series geotextiles provide economical solutions to many civil engineering applications including a cost-effective alternative to graded-aggregate filters.

APPLICATIONS

Mirafi® N-Series nonwoven geotextiles are used in a wide variety of applications including soil separation and drainage applications. Lightweight nonwovens are predominantly used for subsurface drainage applications along highways, within embankments, under airfields, and athletic fields. For these drainage structures to be effective, they must have a properly designed protective filter.

Mirafi® N-Series nonwoven geotextiles eliminate the problems of determining the aggregate gradation required to match soil conditions, finding a convenient and economical source of a specific aggregate gradation, transporting and placing graded aggregate, and assuring that the in-place aggregate gradation provides effective filter performance.

Heavyweight nonwovens are used in critical subsurface drainage systems, soil separation, permanent erosion control, and geomembrane liner protection within landfills. These geotextiles provide the required strength and abrasion resistance to withstand installation and application stresses to create an effective, long-term drainage solution.

INSTALLATION GUIDELINES*

French and Trench Drains Geosynthetic Placement

Cut geosynthetic to proper width prior to placement. Width should be enough to conform to the trench perimeter with at least a 15cm (6in) top overlap. Place the geosynthetic roll over the trench, and unroll enough geosynthetic that the geosynthetic can be placed down into the trench. Anchor the edges of the geosynthetic with heavy objects to prevent the geosynthetic from falling into the trench. Where overlaps are necessary between rolls, allow for 1m (3ft) overlap from the upstream to the downstream roll.

* These guidelines serve as a general basis for installation. Detailed instructions are available from your TenCate™ representative.

Protective & Outdoor Fabrics
Aerospace Composites
Armour Composites
Geosynthetics
Industrial Fabrics
Synthetic Grass

TENCATE™
materials that make a difference

Appendix D

Form - 348 rev. 09/06

UTAH DEPARTMENT OF TRANSPORTATION
WEEKLY EMBANKMENT REPORT

Project Name: Tie Fork Rest Area Turn Lanes-Construct Turn Lanes

Report No. 1

Project No: F-0006(107)185

Week Ending June 6, 2009

Pit or source Existing Material

Material Type Granular Borrow

Material Type* Granular Borrow over Geo Grid Change Order

Item #

Test Date: 5/11/09			T99 T180	Optimum	Soil	Grade Ref.	Corrected	Corrected	Field	%Field	%
Test Sta.	% +3/4	% -3/4	D.D.lbs/ft³	Moisture	Class.	or Thick	D.D.lbs/ft³	Moisture	D.D.	Moisture	compact.
11+40			138	6.8		20' Rt.			128.6	9.6	93.2
13+20			138	6.8		25' Rt.			132.2	7.4	95.8
15+30			138	6.8		20' Rt.			132.1	9.1	95.7
16+15			138	6.8		25' Rt.			135.7	6	98.3
										Avg.	95.8

Test Date: 5/12/09			T99 T180	Optimum	Soil	Grade Ref.	Corrected	Corrected	Field	%Field	%
Test Sta.	% +3/4	% -3/4	D.D.lbs/ft³	Moisture	Class.	or Thick	D.D.lbs/ft³	Moisture	D.D.	Moisture	compact.
18+25			138	6.8					130.6	6.1	94.6
18+32			138	6.8					133.8	7.9	97
18+37			138	6.8					131.8	7.8	95.5
										Avg.	95.7

Test Date: 5/27/09			T99 T180	Optimum	Soil	Grade Ref.	Corrected	Corrected	Field	%Field	%
Test Sta.	% +3/4	% -3/4	D.D.lbs/ft³	Moisture	Class.	or Thick	D.D.lbs/ft³	Moisture	D.D.	Moisture	compact.
24+50	48.4	51.6			A-1-a	10' Rt.					
										Avg.	

Test Date: 6/2/09			T99 T180	Optimum	Soil	Grade Ref.	Corrected	Corrected	Field	%Field	%
Test Sta.	% +3/4	% -3/4	D.D.lbs/ft³	Moisture	Class.	or Thick	D.D.lbs/ft³	Moisture	D.D.	Moisture	compact.
22+75			138	6.8					133.4	5.8	96.7
20+40			138	6.8					137.3	4.9	99.5
19+00			138	6.8					133.1	17.7	96.5
23+00			138	6.8					137.1	9.7	99.4
24+50			138	6.8					138.4	7.3	100
										Avg.	

Test Date:			T99 T180	Optimum	Soil	Grade Ref.	Corrected	Corrected	Field	%Field	%
Test Sta.	% +3/4	% -3/4	D.D.lbs/ft³	Moisture	Class.	or Thick	D.D.lbs/ft³	Moisture	D.D.	Moisture	compact.
										Avg.	

Quantity Previously Reported: _____ Quantity Reported this date: _____ Total Quantity to Date: _____

Remarks: Change order for Granular Borrow over Geo Grid to stabilize base.
Information on Density. Proctor has no correction factor, Material Too Rocky For Density

Project Engineer _____ Date: _____

Appendix E

David Simmons, UDOT Rotational Engineer:

> "the Tensar and Tenax grids [were] nearly identical." He also noticed that “the Tenax grid seems to have less memory than the Tensar grid”.

Kurtis Park, UDOT Engineering Technician IV:

> “The material was too rocky to get a good reading.” Readings, however, did range between 93-94% after the excavator had passed over each lift multiple times. According to Kurtis, “Both manufacturers recommended compacting the first two lifts by passing equipment over the top [as opposed to other consolidation methods]”.