Research Need Statement 555

Date:	**April 30, 2018**
Need Statement Champion:	**LRRB – Brainstorming** **Dan Sarff (City of N. Mankato)** **Jim Johnson (City of Chisholm)** **Jeff Johnson (City of Mankato)**
Agency:	
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Idea Submitted by:	**SRF Consulting Group, Inc. – Michael Marti**
Idea Originated from:	**LRRB 2018 Brainstorming**

Select Program:

☑ MnDOT OR ☑ Local Road Research Board (LRRB)

☑ Research OR ☐ Implementation

Need Statement Title:

Effectiveness of Geotextiles/Geogrids in Roadway Construction; Determine a Granular Equivalent (GE) Factor

Need Statement: Describe the problem or the opportunity. Include background and objective.

Agencies are using geogrids within their road construction. The grids have been effective, especially when constructing in areas of weak/susceptible soil. But, they are costly. Local agencies are asking for assistance in determining the value of geogrids. Specifically, they are asking:

- What is the value of geogrids in terms of benefit costs and value in terms of added strength (assigning a GE factor to the geogrid). MnDOT issued a tech memo in 2015 assigning a GE factor of 2.0 to multi-axial geogrids. Is the GE factor still valid with the improvements in geogrid materials? Should it be increased?
- What conditions are geogrids best used? Many report that they are most cost effective when paving in areas with poor/susceptible soils. However, they are getting questions from elected officials on why they are not using it everywhere? Therefore,
    - What is the value of using a geogrid in areas with good soils?
    - In these areas is there a way to reduce the amount of gravel or asphalt top to make it a more cost-effective solution?
    - Is there a value that can be assigned to the geogrid in terms of granular equivalency?
- Where in a pavement structure is a geogrid most effective? Most feel it is at the interface of the base and subgrade as a separation layer and where added shear stress is needed most. Others are placing it within the aggregate base, and some are reporting placing it within the asphalt layer.
- In addition to the question "Where to place geogrids?" agencies are getting questions/resistance from contractors regarding constructability. Geogrids are fairly stiff and can be difficult to work with (getting them to lay flat, not having edges stick up to get caught/dragged by construction equipment).

- City of Mankato used a geogrid (Tensar) in one of their federal aid projects. They used the vendors design specs/tool for their pavement design but needed to go through a lengthy process to get MnDOT CO to recognize the GE benefit of the geogrid. Although Mankato eventually did get approval; can this project (and others) be used as a case study to develop some type of third party review/approval process to validate the vendor's technical information?

Provide a summary of the potential benefits:

The benefit of this study would be realizing and understanding the structural benefits of geogrids and applying GE factors to a pavement design to reduce the inches of material (gravel and/or asphalt). This reduction of materials could be a significant cost saving per project, not to mention the savings statewide.

How does this project build upon previous research (include title or reference to a completed research effort)?

In 2016, MnDOT completed a study 2016-24, **Implementation of Geogrids During Pavement Design and Construction,** which looked at geogrids and how they worked within MnDOT MnPAVE flexible pavement design software. One specific finding stated:

> The improved analytical process provides mechanistic behavior models for aggregate-geogrid interaction that support reducing aggregate thickness for base courses enhanced with geogrids.

The study went on to further to state:

> Researchers are working to develop a simple table of geogrid gain factors that can be used to adjust pavement designs in projects using geogrids

Additionally, MnDOT has an ongoing study entitled: **Geogrid Specification for Aggregate Base Reinforcement,**" which is working to develop a draft performance specification. The new draft specification would include additional material property specifications that provides stiffness at low strains, in order to better quantify the benefit of different types of geogrid on flexible pavement performance. This new specification would provide a common standard for different geogrid geometries with different rib thicknesses and aperture sizes, which would allow different products by different manufacturers to be compared fairly.

This research will be completed later in calendar year 2018. The results will only focus on MnPAVE design. Further research will be necessary to convert MnPAVE design results into GE factors.

Provide names to consider for a technical advisory panel:

Dan Sarff (City of North Mankato), Jim Johnson (City of Chisholm), Jeff Johnson (City of Mankato), John Siekmeier (MnDOT Materials), Joe Casanova (MnDOT D2), Mike McCarty (City of Mankato); Joel Ulring (State Aid); Tim Andersen (MnDOT Materials); Blake Nelson (MnDOT Materials) Matt Oman (Braun Intertec); Tensar representative

Research Need Statement 555

MINNESOTA DEPARTMENT OF TRANSPORTATION
State Aid Division
Technical Memorandum No. 15-SA-02
December 14, 2015

To:	County Engineers (Distribution 618) City Engineers (Distribution 650) MnDOT District State Aid Engineers MnDOT District Materials Engineers SALT Consultant list
From:	**Mitch Rasmussen**, P.E. State Aid Engineer
Subject:	**Geogrids (multiaxial) on CSAH and MSAS routes - General Specification, Granular Equivalent (G.E.) and Design Guidelines**

Expiration

This Technical Memorandum supersedes Technical Memorandum No. 10-SA-03 and will expire on December 20, 2020 unless superseded prior to this date.

Implementation

The guidelines contained in this Technical Memorandum are effective immediately for all Federal Aid and State Aid projects specifying multiaxial geogrid. This Technical Memorandum **does not** apply to uniaxial geogrids.

Introduction

Plans and proposals should not reference a brand named product. A general specification for multiaxial geogrid will provide designers a framework from which to specify the geogrid engineering properties required for a project.

With limited aggregate sources on some projects, there is an economic need to assign a granular equivalent (G.E.) to a geogrid.

This Technical Memorandum will provide roadway designers with both general information and contact persons regarding the application of geogrids in roadway aggregate base course construction.

Purpose

There are three main purposes of this Technical Memorandum. First, is to provide a general specification for the uses of geogrids. Second, is to provide a granular equivalent (G.E.) for geogrid. Third, is to provide design guidelines for the application of geogrids in the aggregate base course in both MSAS and CSAH routes.

Guidelines

SPECIFICATION

In the plans and proposals, geogrid should be referenced under specification number 2105. Minimum numeric strength values will differ depending on the application and strength of geogrid required.

GRANULAR EQUIVALENT

For aggregate base course design purposes, multiaxial geogrid shall have a maximum granular equivalent (G.E.) value of **2 inches.** Multiple layers of multiaxial geogrid within a pavement design shall not be additive. Maximum G.E. from geogrid = 2 inches.

DESIGN GUIDELINES

Geogrids are a regular network of tensile elements with apertures of sufficient size to interlock with surrounding fill material.

Multiaxial geogrids are typically used in aggregate base courses and have strength in two or more directions. Particles in the aggregate base course may move due to traffic loading causing surface rutting. Multiaxial geogrids are beneficial to use where traffic stresses exceed the aggregate base course lateral restraint capacity causing rutting and alligator cracking.

The geogrid shall not have any distortions or waves in the lay down. For maximum benefit, the geogrid should be installed a minimum of 4 inches and not more than 12 inches beneath the top of the aggregate base. Geogrid should be installed in the aggregate base and not in the granular subbase material. The aggregate base material gradation is extremely important because the aggregate particles need to interlock in the aperture openings of the specified multiaxial geogrid. An aperture dimension range from 0.5 to 1.5 times the largest sieve requirement tends to interlock well.

Construction experience has shown that placing 4 to 8 inches of aggregate base on the geogrid should allow for an adequate construction platform. However, each design should be checked to ensure a stable platform for construction equipment. Aggregate material should initially be placed in the center of the geogrid and then spread outward radially in a uniform depth to the geogrid edges. Tracked construction equipment should not be allowed to drive directly on the geogrid itself.

Consult with your District Materials Engineer, District State Aid Engineer and the manufacturer's recommendations for further guidance.

Questions

For information on the technical contents of this memorandum, please contact either Blake Nelson, MnDOT Geotechnologies Engineer at **(651)366-5599,** Tim Andersen, MnDOT Pavement Design Engineer at **(651)366-5455** or Joel Ulring, MnDOT State Aid Pavement Engineer at **(651)366-3831.**

A link to all active and historical State Aid for Local Transportation Technical Memoranda can be found at: http://www.dot.state.mn.us/stateaid/sa_tech_memos.html

Attachment: General specification (2105) GEOGRID for multiaxial applications only (2 pages). For uniaxial applications the designer must write a project specific specification.

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2105
GEOGRID

2105.1 Description

This work consists of placing multiaxial geogrid(s) for construction in accordance with the details shown in the plan, the applicable MnDOT Standard Specifications, and the following:

2105.2 Materials

The multiaxial geogrid must meet the following strength values in accordance with ASTM D 6637.

Geogrid Type		Type A	Type B
Minimum Tensile strength at 2% strain	Longitudinal*	See note 1 below	410 lb/ft (6.0 kN/m) minimum
	Transverse**	See note 1 below	615 lb/ft (9.0 kN/m) minimum
Minimum Ultimate Tensile Strength	Longitudinal*	See note 1 below	1310 lb/ft (19.2 kN/m) minimum
	Transverse**	See note 1 below	1970 lb/ft (28.8 kN/m) minimum

Type A – Note 1: values as agreed upon by MnDOT Geotechnologies Engineer

Type B – Use only for aggregate base reinforcement

Junction Strength – 25 lb. (111 N) maximum

Minimum Aperture Dimensions: 0.5 x largest sieve requirement

Maximum Aperture Dimensions: 1.5 x largest sieve requirement

*machine direction

** cross machine direction or specified direction

2105.3 Construction Requirements

1. The installation operation must not cause damage, distortion to, or compromise the performance of the geogrid in any manner.
2. Geogrid, Type B, will be placed parallel to the centerline of the roadway.
3. The minimum overlap of geogrid is 1.0 ft. (0.3m) and must be tied with mechanical connectors, spaced at a maximum interval of 4 ft. (1.3m). Use mechanical connectors as approved by the manufacturer.

2105.4 Method of Measurement

Measurement will be made by the area of geogrid placed (no compensation for overlaps) as specified.

2105.5 Basis of Payment

The contract bid price per square yard (square meter) is full compensation for the cost of furnishing and installing the required materials, including mechanical connectors.

Payment will be made under:

Item No.	Item	Unit
2105.604	Geogrid	Square yard (square meter)

Revised: 11/6/2015

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Date: Thursday, April 05, 2018
Prepared for: Nicole Buehne
Prepared by: Jim Byerly, Electronic Resources Librarian
Resources searched: Transport Database, Research in Progress, Web, MnDOT Library Catalog, ASCE Library
Summary: Results are compiled from the databases named above. Links are provided for full-text, if applicable, or to the full record citation. I completed my searches using the following terminology: geogrid, cost benefit, benefit cost. The results are divided into most relevant and less relevant.

1. **Geogrids in Roadway and Pavement Systems**
   http://globalsynthetics.com.au/wp-content/uploads/2016/01/Global-Synthetics-**Geogrids**-in-Roadway-Pavement-Systems.pdf

2. **Application of risk, cost–benefit and acceptability analyses to identify the most appropriate geosynthetic solution to mitigate sinkhole damage on roads**
   http://www.academia.edu/28860683/Application_of_risk_cost_benefit_and_acceptability_analyses_to_identify_the_most_appropriate_geosynthetic_solution_to_mitigate_sinkhole_damage_on_roads

3. **Incremental Costs and Performance Benefits of Various Features of Concrete Pavements**
   https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/04044/04044.pdf

4. **Geogrid Reinforcement of Asphalt Pavements.**
   Source: Baltic Journal of Road and Bridge Engineering. 2017. 12(3) pp 181-186 (Refs.)
   URL: http://dx.doi.org/10.3846/bjrbe.2017.22
   Abstract: Geogrid materials applied within asphalt layers defer or prevent the occurrence of reflective cracking. The contribution of this work significantly adds to extending pavement serviceability and improving benefit/cost analysis. Since 1970s many studies have demonstrated the benefits of geogrid reinforcement in asphalt pavements, but this knowledge did not translate to their extensive usage in the actual construction practice. Among potential reasons are higher initial costs, lack of in-depth understanding of working mechanism within adjacent asphalt layers and lack of commonly standard design procedures. This paper presents a recent study, which investigated the effect of geogrid reinforcement on asphalt mixture specimens. Two types of laboratory experiments were conducted, namely monotonic (strength and fracture) testing and cyclic (fatigue and modulus) testing. The results demonstrated a significant strengthening contribution of geogrid, which was observed regarding fracture energy results and terminal deflections in the fatigue testing. This paper also presents a short example connecting pavement deflections with the allowable axle loading (also known as fatigue life) to demonstrate the practical implications of geogrid reinforcement. The undertaken analysis shows the reduction of pavement deflections due to the geogrid application, which potentially leads to a significant extension of pavement fatigue life. Paper concludes with several recommendations for further work in the area of geogrid reinforcement.
   Year: 2017

5. **Application of Geosynthetics on Low-Volume Roads.**
   Source: Transportation Geotechnics. 2016/9. 8 pp 119-131
   URL: http://dx.doi.org/10.1016/j.trgeo.2016.04.002
   Abstract: There are numerous cost-effective applications for geosynthetics on low-volume roads, yet geosynthetic materials use on these roads is typically underutilized. The USDA Forest Service has been using geosynthetics on its low-volume roads for the past 40 years in applications of separation, reinforcement, drainage, filtration, and others. The objective of this paper is to document many of these uses on low-volume forest roads, both traditional and unique, and discuss

the many cost-effective advantages of geosynthetic use. Uses in low-volume road applications are similar to those used in many highway projects and have many of the same benefits and cost savings, yet utilization is variable and inconsistent. In many developing countries, engineers and technicians designing rural roads have barely heard of geosynthetic materials, much less taken advantage of their benefits. Low volume roads make up roughly two thirds of all the roads worldwide, or roughly 30 million kilometers of roads, yet they do not receive the attention and appropriate technologies deserving of such a major amount of infrastructure. Significant cost savings and improvements in design and ultimately roadway performance can be realized with the increased use of geosynthetics in underdrains, for subgrade reinforcement, in geosynthetically reinforced retaining structures, and in improved erosion control. Materials used include geotextiles, geogrids, geocells, geofoam, netting, and other geosynthetics.
Year: 2016

6. **Geosynthetic Solutions for Paved and Unpaved Applications.**
   Source: Conference Title: Shale Energy Engineering Conference 2014. Location: Pittsburgh. Sponsored by: American Society of Civil Engineers. Held: 20140721-20140723. 2014/5. pp 565-575 (Figs., Phots., Refs.)
   URL: http://dx.doi.org/10.1061/9780784413654.059
   Abstract: Geogrid use at current US drilling facilities within the Marcellus and Utica Shale regions, as well as lesser publicized shale formations, have given the operators and producers a way to increase the performance of their access roads and well pads. Within this market, the construction costs for these roads have increased dramatically as a direct result of the presence of areas of soft soil or unforeseen environmental impacts (e.g., cold weather). Since some of these companies have started to include geogrids into their road and well pad sections, the time for construction has been reduced, the road and well pad have been and remain stabilized and, most importantly, their construction costs have been greatly reduced. One producer in PA has saved $1.4 million in construction costs and still maintains an incredible access road that requires little to no maintenance. This paper explains how geogrids enhance performance over conventional construction methods and documents this performance through the inclusion of case histories that will help more companies in the Oil and Gas Market better understand how they can utilize this same approach in their current operations.
   Year: 2014

7. **Down to Earth.**
   Source: Better Roads. 2014/5. 84(5) pp 5, 7-8,10 (Figs., Phots., Tabs.)
   URL: http://www.betterroads.com/down-to-earth-2/
   Abstract: Geosynthetic products can help construction to be faster and more cost-effective, while increasing the service life of structures. Geosynthetics can separate good materials from bad and help facilitate drainage, both of which will improve pavement performance. Different types of geosynthetics have different functions, but all are manufactured polymeric materials used with rock, soil, or other geotechnical material in construction and engineering projects. A recent project in a remote part of Arizona showed the benefit of geosynthetics when the Arizona Department of Transportation had to open an alternate route when a road had to be closed due to a landslide. Use of a geogrid helped save money and time in paving a detour road.
   Year: 2014

8. **Reinforced Soil Retaining Walls in the Mina Al Fajer Resort Project, Fujairah,**
   Source: Conference Title: Geo-Shanghai 2014. Location: Shanghai. Held: 20140526-20140528. 2014/5. pp 471-480 (Refs.)
   URL: http://dx.doi.org/10.1061/9780784413401.047
   Abstract: Dhs 800 m (USD 218 m) Mina Al Fajer Resort project commenced in June 2007. The project - covering an area of 777,025 square feet - includes a marina, mountain villas, solarium

villas, marina apartments and a five-star hotel. The layout of the mountain villas was designed to form a number of rows of villas at different levels forming terraces up the hillside on the sea-front. The mountain villas and the road connecting the terraces at different levels required construction of retaining walls up to 18-m heights and having an overall face area of 20,000 msuperscript 2. Based on successful completion of a number of projects in the same region, TensarTechTW1 (ME) Wall System was chosen by the client. Some of the challenges facing the designer were: (1) the design of the reinforced soil structures to support structures with low tolerance to movement, such as concrete housing frames and swimming pools; (2) limited available space for geogrid placement; (3) tight construction schedule; and (4) architectural project requirements comprising frequent and acute corners on the wall layout. The chosen TensarTech TW1 (ME) Wall System proved to be a very successful solution that is inherently flexible enough to deal with the project requirements and resulting in cost-effective and maintenance-free structures designed to last for 120 years.
Year: 2014