Geogrids for Roadway Applications

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Brief History of Geotextiles & Geogrids

- Geosynthetics – numerous categories based on function
  - Geotextiles – textile fabrics
    - First used late 1950’s in Europe
    - Became widespread in USA during 1970’s
  - Geogrids – open mesh, grid structure
    - Developed shortly after geotextiles began widespread use
    - Tensar introduced to USA in early 1980’s

- Many similarities and many differences
Geotextile / Geogrid Types and Manufacturing

- **Materials**
  - Polypropylene, high-density polyethylene, polyester
  - PVC & polymer coatings

- **Manufacturing processes**
  - Extruded-punched-and-drawn
  - Slit film, monofilament, multifilament (yarn)
  - Woven
  - Needle punched, non-woven
  - Knit
  - Welded
Function and Performance Mechanisms
Geotextiles

FIG. 10.—Kinematics of Unpaved Road with Geotextile

Source: Geotextile-Reinforced Unpaved Road Design – Giroud-Noiray
Function and Performance Mechanisms
Geotextiles

- Load distribution
- Soil separation
- Tensioned Membrane Effect
“…lateral restraint has been identified as the primary reinforcement mechanism…”

Source: USACOE ETL 1110-1-189
Function and Performance Mechanisms
Geogrids

Lateral Restraint resists aggregate particle movement under load
Lateral Restraint
- Mechanical Interlock & Lateral Confinement
  - Rib profile
  - Stiff junctions
  - Geogrid/fill compatibility
- FHWA Guideline:
  \[ D_{50} \leq \text{Aperture Size} \leq 2D_{85} \]
Function and Performance Mechanisms
Geogrids

Improved Bearing Capacity

Unreinforced Shear Surface

Reinforced Shear Surface

Source: USACOE ETL 1110-1-189
“Geogrid improves the ability to obtain compaction in overlying aggregates”
Function and Performance Mechanisms
Geogrids

Separation

This phenomenon of soil migration is called piping, and relatively simple geometrical relationships quantify whether or not distributed pore spaces within a particular aggregate fill are small enough to hold the finer soil particles of a particular subgrade in place. The concept is illustrated in Figure 3 (Cedergren, 1989).
Function and Performance Mechanisms

Geogrids

Separation

- D15 (filter)
- D85 (subgrade)
- Subgrade
- Nominal boundary before movement
- Water Movement

Piping Ratio Calculation

Subgrade (Georgia Red Clay)
Pl = ~20 – 25
D15f/D85s
= 0.22/0.62
= 0.4 < 5

D85 = 0.62mm
D15 = 0.22mm

% Finer by Weight

- 3" Gravel
- #4 Sand
- #200 Silt & Clay
Geogrids for Roadway Applications

Geogrid enhances:

- Stiffness and resiliency of aggregate and granular fill
- Load distribution
- Rutting resistance under repeated loads
- Bearing capacity and settlement resistance
- Separation of dissimilar soils
Geogrids for Roadway Applications

Benefits of using geogrid:

- Reduce aggregate thickness
- Reduce or eliminate undercut
- Expedite construction
- Cost-effective alternative to cement
- Improved performance relative to geotextile fabrics

Where to use:

- Beneath or within aggregate and granular fill
- Paved and unpaved roads
- Above and below utilities
- Whole roadway or isolated areas
Geogrids for Roadway Applications

Subgrade Improvement:
- Establish stable working platform
- Support construction equipment without disturbing subgrade

Aggregate Base Reinforcement:
- Stiffen aggregate base
- Extend roadway life
- Prevent base failure
Roadway Applications

Unpaved road
Roadway Applications

Unpaved road
PROPOSED TYPICAL
STA. 12+04 TO STA. 278+82

(32' Wide)
12" Subgrade Preparation

(25' Wide)
Geogrid

29" Graded Roadway

24" Aggregate Top

10" Aggregate Surface Course CL 13 (22,083.3 SF)

Topsoil

4'7" or Flat
PROPOSED TYPICAL SECTION

SOUTH HEART RD

STA 14+75.55 TO 336+90.75

DESIGN SPEED 55 MPH
GEOSYNTHETIC MATERIAL TYPE G (30' WIDE)

PROPOSED TYPICAL SECTION B (RECONSTRUCTION)
STA. 40+40 TO 47+70
STA. 48+33 TO 53+33
STA. 177+20 TO 186+25
Roadway Symmetrical about C

12" Subgrade Preparation - 95% T-99

Geotextile Fabric Type R1 - 40' wide

7" Hot Bituminous Pavement - CL 33
Area = 17.50 SF Paved in 4 lifts.
(2 - 2.5" lifts and 1 - 2" wear course)

18" Aggregate Base Course CL 5
Area = 57.00 SF
7'' Hot Bituminous Pavement CL 33
Area = 17.5 SF Paved in 4 lifts.
(2 - 2.5'' lifts and 1 - 2'' wear course)

12'' Cement Treated Base
Area = 38.00 SF

12'' Subgrade Preparation - 95% T-99
7" Hot Bituminous Pavement
Area = 17.5 SF Paved in 4 lifts.
(2 - 2.5" lifts and 1 - 2" wear course)

14" Aggregate Base Course CL 5
Area = 44.33 SF

Geotextile Fabric - Type R2
Width = 40 ft

12" Subgrade Preparation - 95% T-99
Roadway Applications

Structure & utility support
Roadway Applications

Structure & utility support

![Diagram of roadway application with geogrid reinforcement and compaction layers.]
Roadway Applications

Structure & utility support
Roadway Applications

Construction Entrance

SECTION A-A

TENSAR TX160 GEOGRID
(SEE NOTES 1 & 2)

CL5 AGGREGATE BASE
(SEE NOTE 3)

OPEN-GRADED STONE SURFACE
2” – 4” STONE SIZE
(SEE NOTE 4)

3” MINIMUM
(SEE NOTE 4)

6” MINIMUM COMPACTED CL5 AGGREGATE OR SIMILAR
(SEE NOTE 3)

SUBGRADE
Standard Practice for

Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures

AASHTO Designation: R 50-09

1. SCOPE

1.1. This standard practice provides guidance to pavement designers interested in incorporating geosynthetics for the purpose of reinforcing the aggregate base course of flexible pavement structures. Geosynthetic reinforcement is intended to provide structural support of traffic loads over the life of the pavement.

1.1.1. For the purpose of this guide, base reinforcement is the use of a geosynthetic within, or directly beneath, the granular base course.

1.1.2. When referring to geosynthetics, the discussion is limited to geotextiles, geogrids, or geogrid/geotextile composites.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standard:
   - M 288, Geotextile Specification for Highway Applications

2.2. Other References:

3. INTRODUCTION

3.1. Because the benefits of geosynthetic reinforced pavement structures may not be derived theoretically, test sections are necessary to obtain benefit quantification. Studies have been done that demonstrate the value added by a geosynthetic in a pavement structure. These studies, necessarily limited in scope, remain the basis for design in this field.

3.2. This standard practice is very empirical in nature and restricted to applications already demonstrated to be useful. The practitioner will need to consult the references and locate a tested...
“Use of Geogrids in Pavement Construction”
Engineering Technical Letter (ETL) 1110-1-189
Department of the Army, US Army Corps of Engineers (USACE)

“Extruded geogrids have shown good performance when compared to other types for pavement reinforcement applications.”

Geogrid’s primary uses are… “(a) serve as a construction aid over soft subgrades, (b) improve or extend the pavement’s projected service life, and (c) reduce the structural cross section for a given service life.”

“Geogrid improves the ability to obtain compaction in overlying aggregates, while reducing the amount of material required to be removed and replaced.”

“The ability of a geogrid to separate two (dissimilar) materials is a function of the gradations of the two materials.”
## Table 5
Reinforced Bearing Capacity Factors, $N_c$, for Aggregate-Surfaced Pavements

### Step 1: Determine Design Subgrade Soil Strength and Geosynthetic Applicability

<table>
<thead>
<tr>
<th>CBR</th>
<th>0.5 &lt; CBR &lt; 2.0</th>
<th>2.0 &lt; CBR &lt; 4.0</th>
<th>CBR &gt; 4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use a geotextile and a geogrid at subgrade-base interface. No aggregate thickness reduction recommended. Use TM 5-822-12 for thickness design.</td>
<td>Both a geotextile and a geogrid are recommended. Use this design procedure for aggregate thickness reduction.</td>
<td>A geotextile is required for fine-grained subgrades. A geogrid may also be cost-effective. Perform a life cycle cost analysis.</td>
</tr>
<tr>
<td>Geotextile</td>
<td>Geogrid</td>
<td>Geotextile</td>
<td>Geogrid</td>
</tr>
<tr>
<td>5.0&lt;sup&gt;3&lt;/sup&gt;</td>
<td>5.8</td>
<td>5.8</td>
<td>5.0&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup>The unreinforced bearing capacity factor, $N_c$, is 2.8.

<sup>2</sup>Both a geotextile and a geogrid are recommended. The geotextile serves primarily as a separation fabric.

<sup>3</sup>Use a factor of 3.6 for conservative geotextile-reinforced pavement designs.
Figure 4 – Relationship between cone index, CBR, and shear strength (p. 7)
Tandem Axle Gear Weight
One Layer System
Tire Pressure = 80 psi

Tandem Wheel Gear Weight
- 43,750 lbs
- 37,500 lbs
- 24,000 lbs
- 17,500 lbs
- 8,000 lbs

Adapted From Steward et al. 1977

a = Radius of Contact Area
3a = 54"

Subgrade Bearing Capacity, CN, psi

Required Aggregate Depth, in.
For a detailed explanation of the design methodology used, please see the reference document 'Development and Empirical Basis of Pavement Optimization Using Tensar TriAx Geogrids', available from the Help menu above.
Aggregate Thickness Requirements for a Typical Unpaved Applications Scenario

Rut Depth = 1 1/2 Inches

Given:
Axle Load = 20 kips
Tire Pressure = 100 psi
No. Passes = 1,200
Subbase CBR = 20 (min.)

Subgrade Consistency:
- soft
- medium
- stiff

Thickness Requirements (in.) vs. Subgrade CBR (see “NOTE” on reverse side)
# Guide for Estimating Subgrade Soil Strengths (Fine-Grained Soils)

<table>
<thead>
<tr>
<th>Estimated Consistency by:</th>
<th>Estimated Consistency by:</th>
<th>Test by:</th>
<th>Correlates to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment/Visual</td>
<td>Standard Penetration Test (blows/ft)</td>
<td>Dynamic Cone Penetrometer</td>
</tr>
<tr>
<td>Very Soft</td>
<td>Man standing sinks &gt; 3 inches</td>
<td>&lt; 2</td>
<td>—</td>
</tr>
<tr>
<td>Soft</td>
<td>Man walking sinks ~ 2 - 3 inches</td>
<td>2 - 4</td>
<td>—</td>
</tr>
<tr>
<td>Medium</td>
<td>Man walking sinks ~ 1 inch</td>
<td>4 - 8</td>
<td>—</td>
</tr>
<tr>
<td>Stiff</td>
<td>Pickup truck ruts ~ 1/2 - 1 inch</td>
<td>8 - 15</td>
<td>&gt; 3.9</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>Loaded dump truck ruts ~ 1 - 3 inches</td>
<td>15 - 30</td>
<td>3.9 - 2.2</td>
</tr>
<tr>
<td>Hard</td>
<td>Insignificant ruts from loaded dump truck</td>
<td>&gt; 30</td>
<td>2.2 - 1.1</td>
</tr>
</tbody>
</table>

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**Note:** The values in the table are estimates and may vary depending on the specific conditions and testing methods used. Always consult with a professional for accurate and reliable data.
## DCP TEST DATA

### Project:

Location: 

### Date:

Soil Type(s): High plasticity Clay

<table>
<thead>
<tr>
<th>No. of Blows</th>
<th>Accumulative Penetration (mm)</th>
<th>Type of Hammer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>270</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>400</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>600</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>750</td>
<td>1</td>
</tr>
</tbody>
</table>

![CBR Graph](image)

*DEPTH, in.*

*DEPTH, mm*

*0.1*  

*1.0*  

*10.0*  

*100.0*  

*0.016*  

*0.1*  

*1.0*  

*10.0*  

*100.0*  

*0.016*
SECTION 709
GEOSYNTHETICS

709.01 DESCRIPTION
This work consists of furnishing and installing geosynthetics.

709.02 EQUIPMENT
Reserved.

709.03 MATERIALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geosynthetics</td>
<td>858</td>
</tr>
</tbody>
</table>

Table 858-03
Geogrid Geosynthetics

<table>
<thead>
<tr>
<th>GEOGRID PROPERTY</th>
<th>TEST METHOD</th>
<th>GEOGRID TYPE G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture Size</td>
<td>ID Calipered</td>
<td>0.5 - 1.5 inch</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D 6637</td>
<td>400</td>
</tr>
<tr>
<td>@ 2% Strain, lb/ft, min.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D 6637</td>
<td>800</td>
</tr>
<tr>
<td>@ 5% Strain, lb/ft, min.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultimate Tensile</td>
<td>ASTM D 6637</td>
<td>1,300</td>
</tr>
<tr>
<td>Strength, lb/ft, min.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. Geosynthetic Geogrid (Type G).

Table 858-03
Geogrid Geosynthetics

<table>
<thead>
<tr>
<th>GEOGRID PROPERTY</th>
<th>TEST METHOD</th>
<th>GEOGRID TYPE G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction Strength</td>
<td>GRI² GG2</td>
<td>25</td>
</tr>
<tr>
<td>(After 500 hrs), % Strength Retained</td>
<td>ASTM D 4355</td>
<td>70</td>
</tr>
</tbody>
</table>

¹ Strength values represent weakest principal direction
² Geosynthetic Research Institute
Overlap the geogrid a minimum of 30 inches at all splices or joints. Construct joints at the end of a roll so the previous roll laps over the subsequent roll in the direction of the cover material placement. Mechanically tie transverse joints at 3 foot intervals, and longitudinal joints at 15 foot intervals. Place pins or staples at all corners and at 15 foot intervals along all edges, before placing cover material on the geogrid.
Site Preparation

- Clear and grub
- Strip topsoil and other unsuitable material if necessary
- Avoid subgrade disturbance if existing/plan grades allow
- Lightly roll or backdrag to smooth ruts
Placing and Overlapping Geogrid

- Shingle in the direction of fill placement

- Plastic or wire ties may be used to secure overlaps
  - These are non-structural, only for ease of construction
  - Most helpful on extremely soft subgrades

- Geogrid may exhibit “roll memory”
  - Pins, staples, or small piles of aggregate may be used to secure
    - Not required
# Summary of Tensar® TriAx® Geogrid Installation Parameters

<table>
<thead>
<tr>
<th>Subgrade Strength</th>
<th>Clear All Vegetation?</th>
<th>Geogrid Orientation(^3)</th>
<th>Geogrid Overlap(^4)</th>
<th>Nylon Zip Ties?(^1,2)</th>
<th>Direct Traffic?(^5)</th>
<th>Geotextile?(^6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBR (\leq 0.5)</td>
<td>N</td>
<td>T or L</td>
<td>3 ft</td>
<td>Y</td>
<td>N</td>
<td>Analysis Req’d</td>
</tr>
<tr>
<td>(0.5 \leq CBR \leq 2)</td>
<td>Usually</td>
<td>L</td>
<td>2-3 ft</td>
<td>N</td>
<td>N</td>
<td>Analysis Req’d</td>
</tr>
<tr>
<td>(2 \leq CBR \leq 4)</td>
<td>Y</td>
<td>L</td>
<td>1-2 ft</td>
<td>N</td>
<td>Limited</td>
<td>Analysis Req’d</td>
</tr>
<tr>
<td>(4 \leq CBR)</td>
<td>Y</td>
<td>L</td>
<td>1 ft</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Summary is a generalized presentation; see text for specifics.
2. Y = Yes, normally required; N = No, not normally required.
4. General Geogrid Overlap Rule: Overlap = 3 ft for CBR \(\leq 1\); Overlap = 1 ft for CBR \(\geq 4\); interpolate between.
5. Direct Traffic pertains only to conventional rubber-tired equipment.
6. Analysis Required = Geotextile required only if filtration criteria is not met by aggregate fill.
Geogrid Overlaps

PROPOSED TYPICAL
STA. 12+04 TO STA. 278+82
Fill Placement

- 6” minimum compacted thickness recommended
  - 8” recommended for CL5 / CL13 subjected to traffic

- Dump at or before edge of exposed geogrid

- Spread with dozer (preferred) or grader

- Rubber tires directly on geogrid is acceptable (avoid turning)

- No tracked equipment directly on geogrid

- Advance fill ahead and to the edges of geogrid

- Some “waving” in geogrid ahead of fill placement is normal
  - Excessive pinning and tying can create problems

- Compact using standard equipment and procedures
Spreading Aggregate
Spreading Aggregate
- Bismarck
- Fargo
- Minot