Geogrids for Roadway Applications

NDLTAP Roundtable Meeting – Killdeer ND – February 24, 2015

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NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

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Brief History of Geotextiles & Geogrids

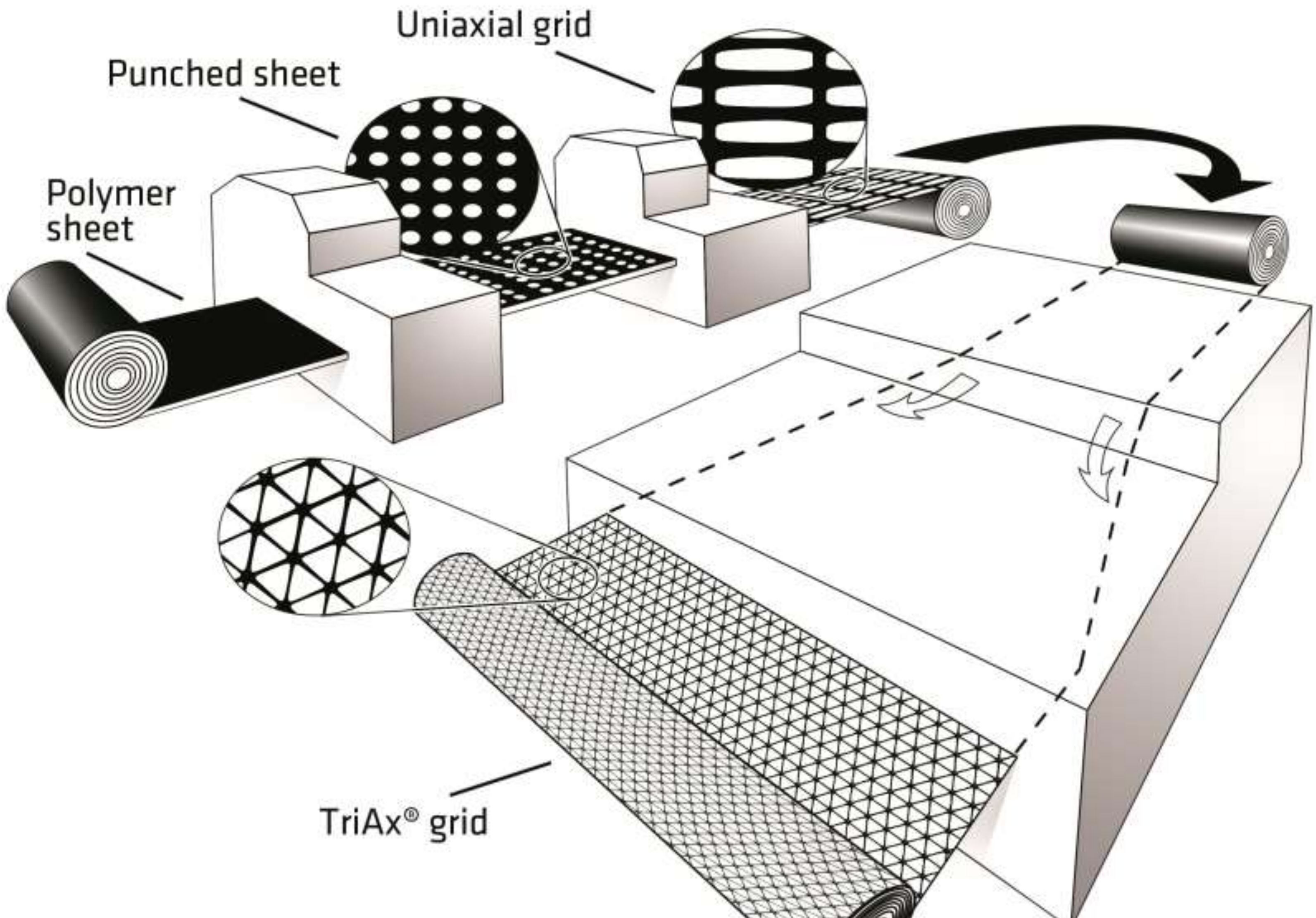
Tensar

- 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



Uniaxial grid
Punched sheet
Polymer
sheet
TriAx® grid

Function and Performance Mechanisms
Geotextiles

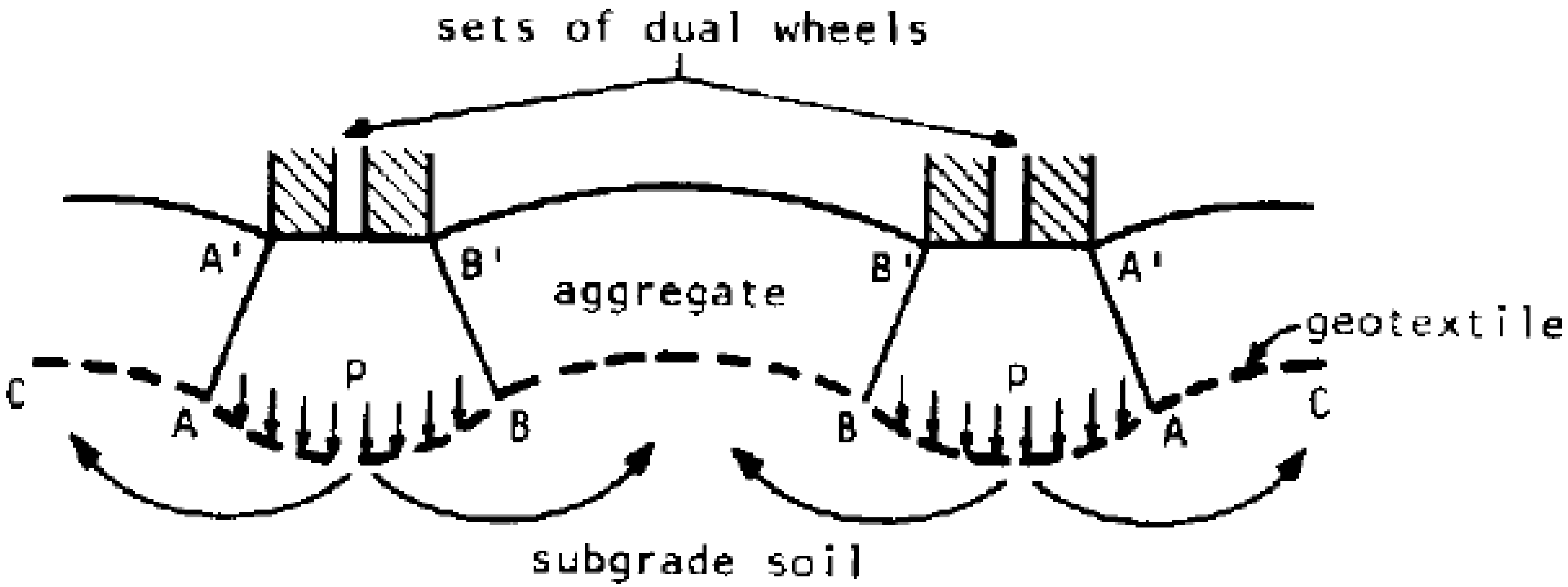
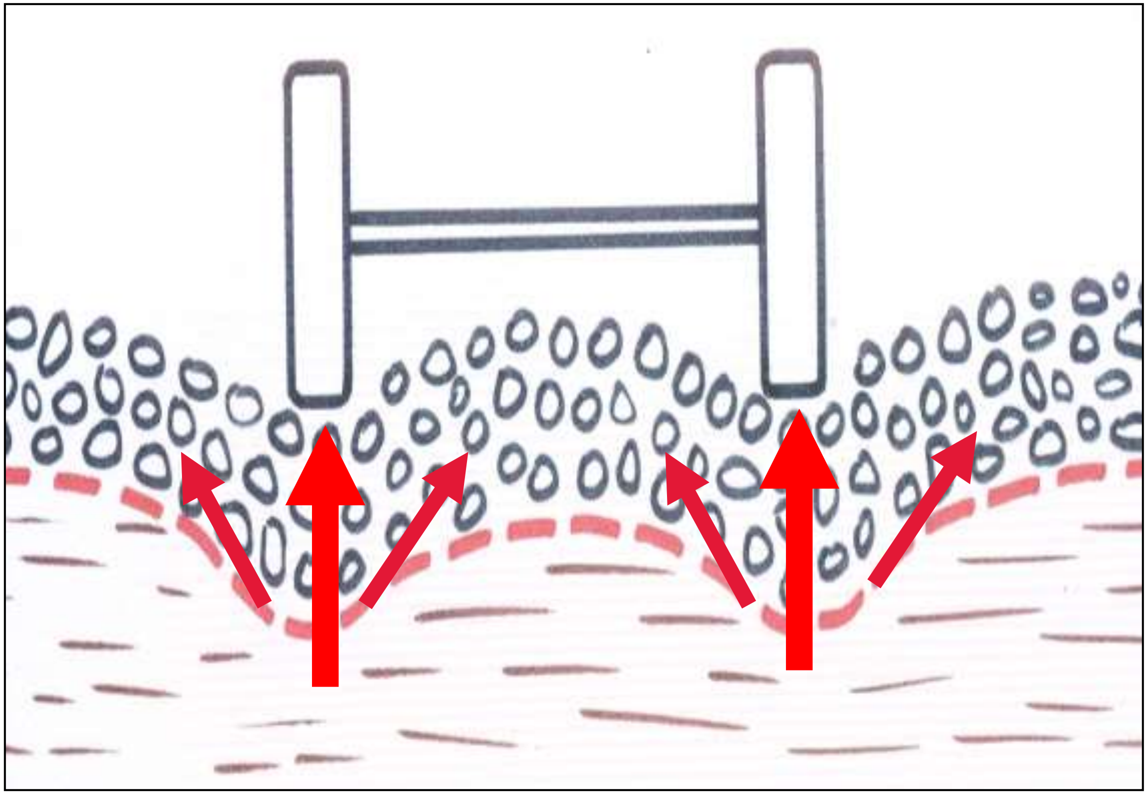


FIG. 10.—Kinematics of Unpaved Road with Geotextile

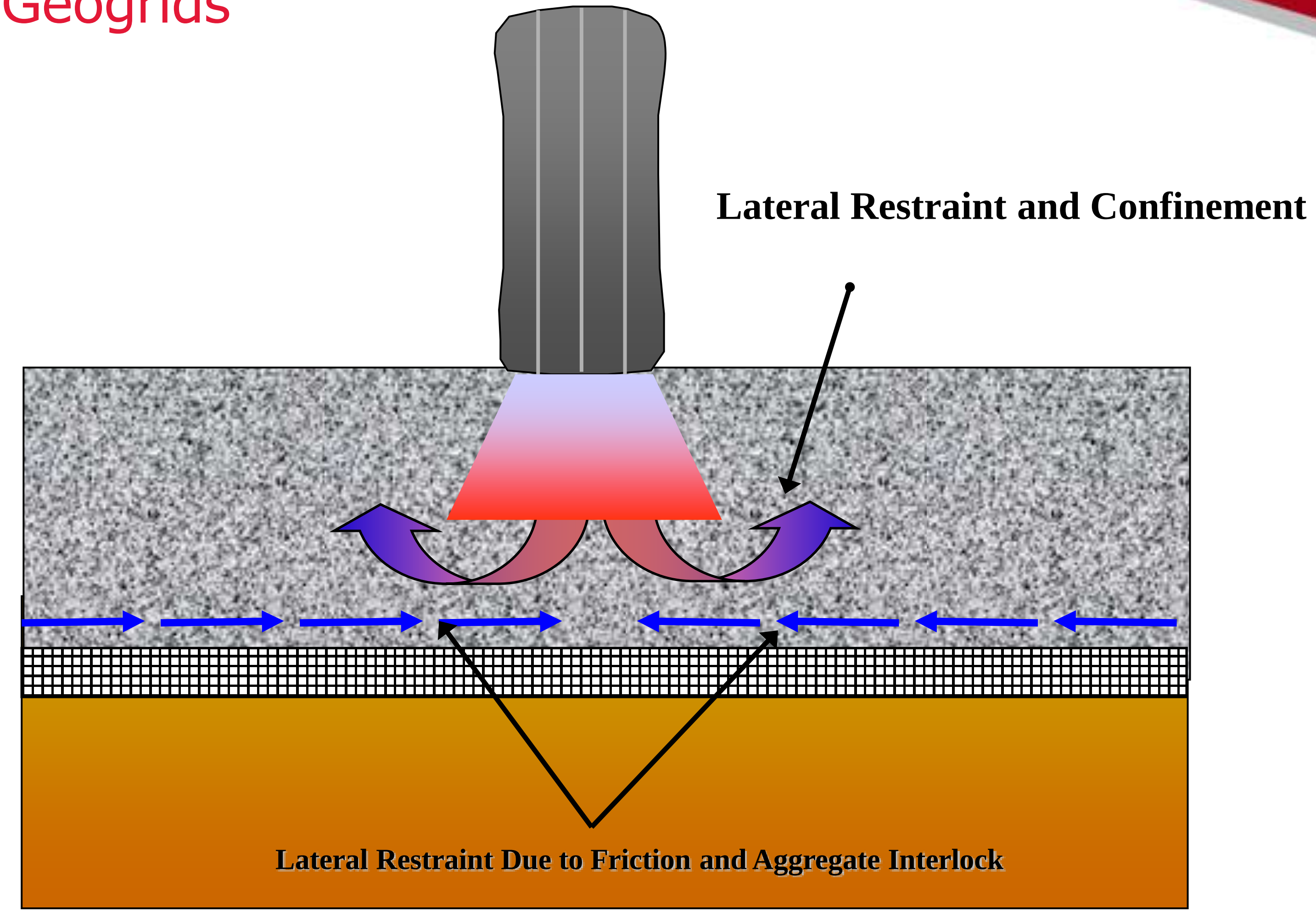
Source: Geotextile-Reinforced Unpaved Road Design – Giroud-Noiray

Function and Performance Mechanisms Geotextiles



- Load distribution
- Soil separation
- Tensioned Membrane Effect

Function and Performance Mechanisms
Geogrids

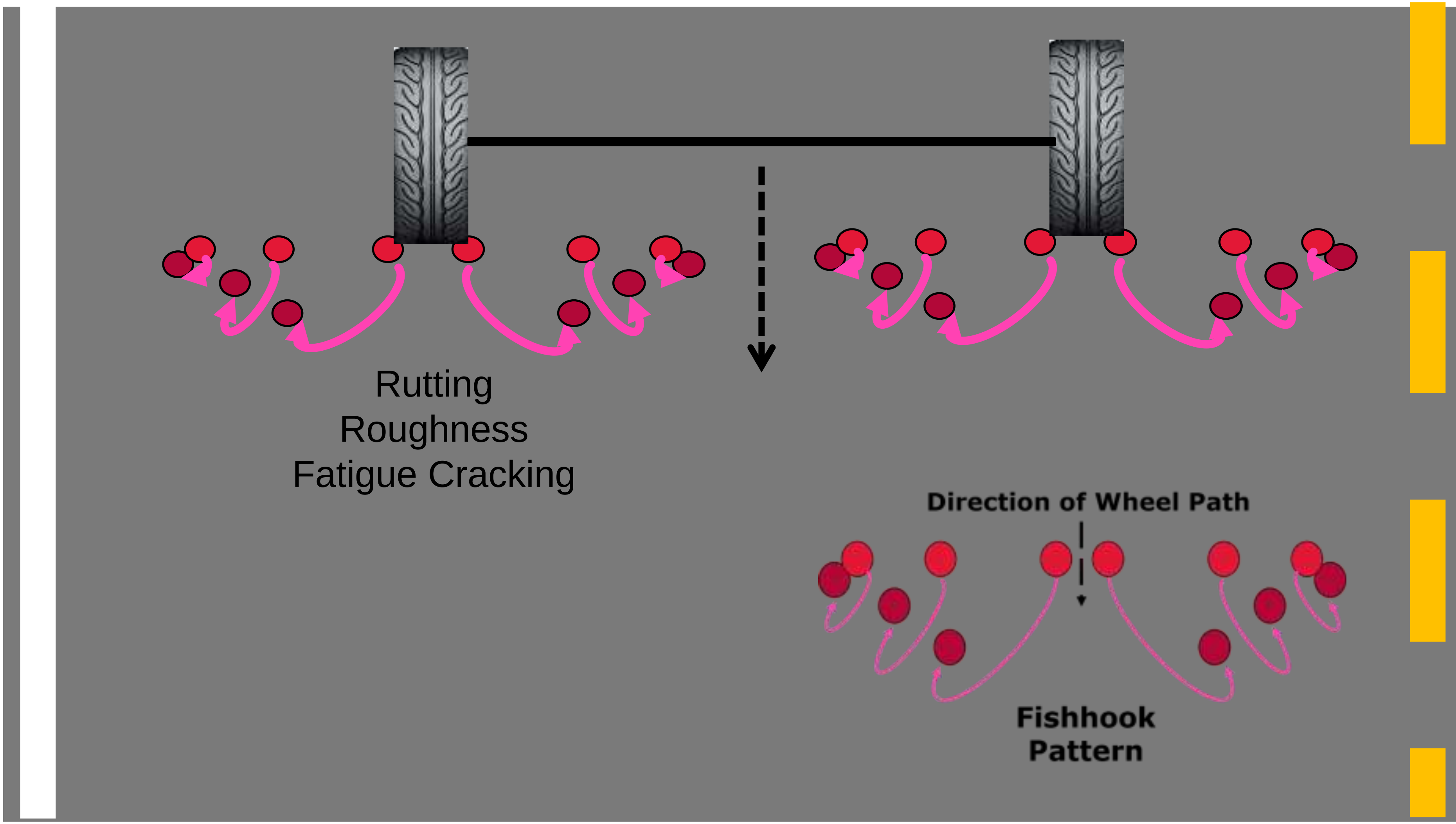


"…lateral restraint has been identified as the primary reinforcement mechanism…"

Source: USACOE ETL 1110-1-189

Function and Performance Mechanisms
Geogrids

Lateral Restraint resists aggregate particle movement under load

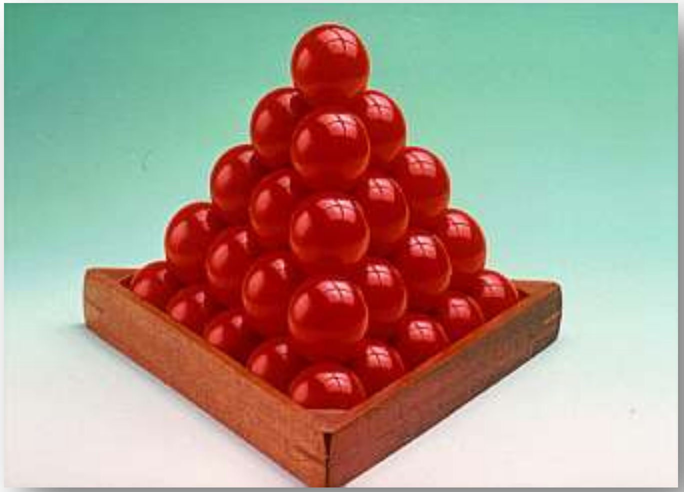


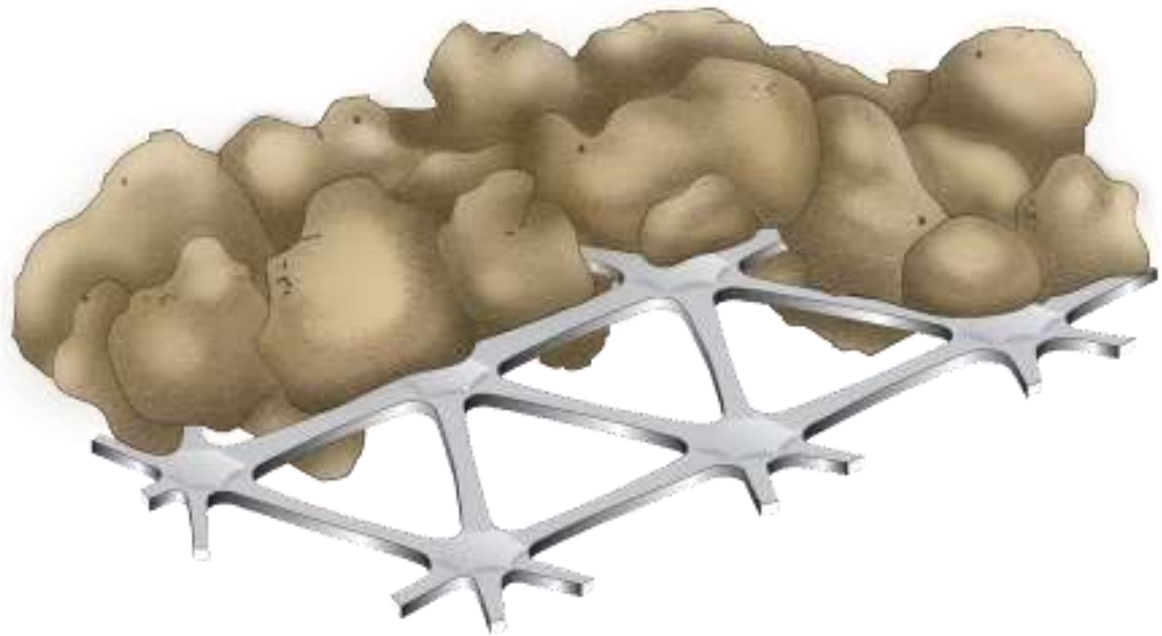
Function and Performance Mechanisms
Geogrids

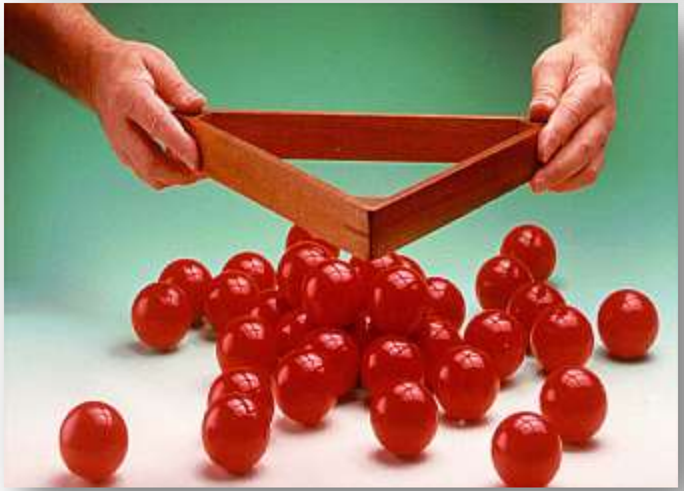
Lateral Restraint

- Mechanical Interlock & Lateral Confinement
  - Rib profile
  - Stiff junctions
  - Geogrid/fill compatibility
  - FHWA Guideline:

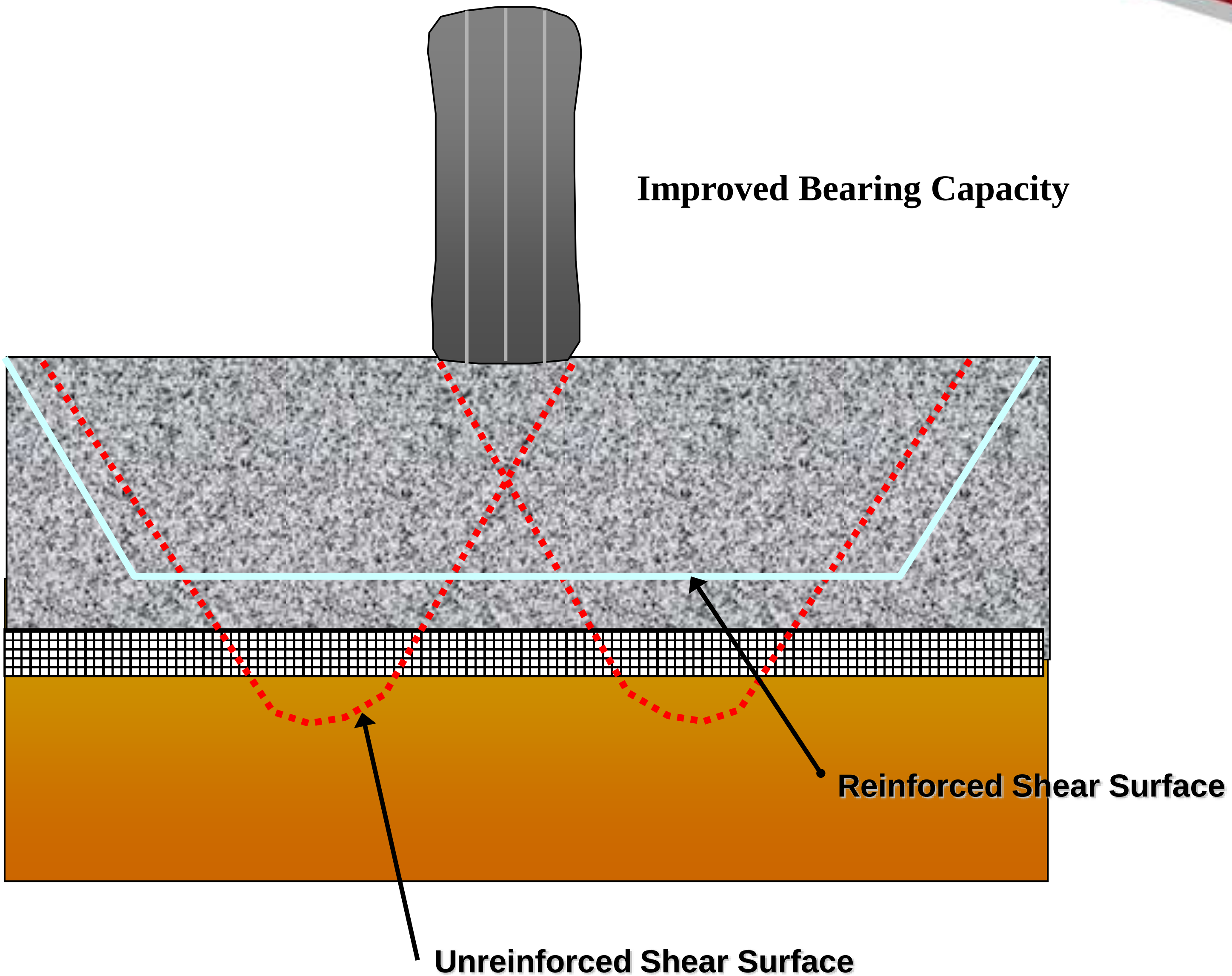
    $D_{50} \leq$ Aperture Size $\leq 2D_{85}$







Function and Performance Mechanisms
Geogrids

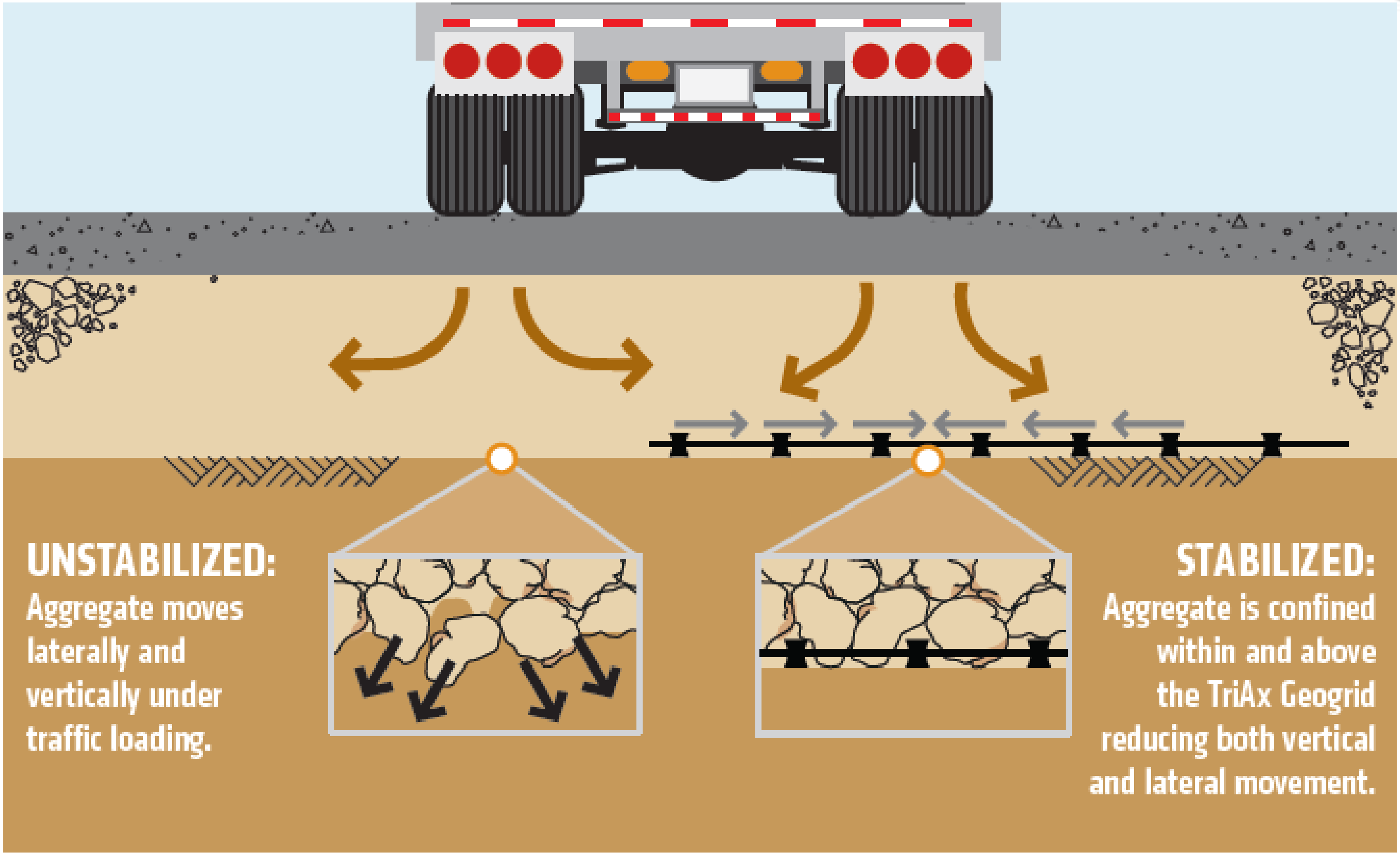


Source: USACOE ETL 1110-1-189

Sandbox Demonstration

CAT 733

Function and Performance Mechanisms
Geogrids



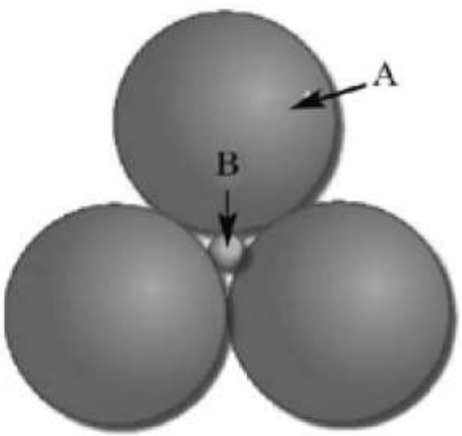
"Geogrid improves the ability to obtain compaction in overlying aggregates"

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).

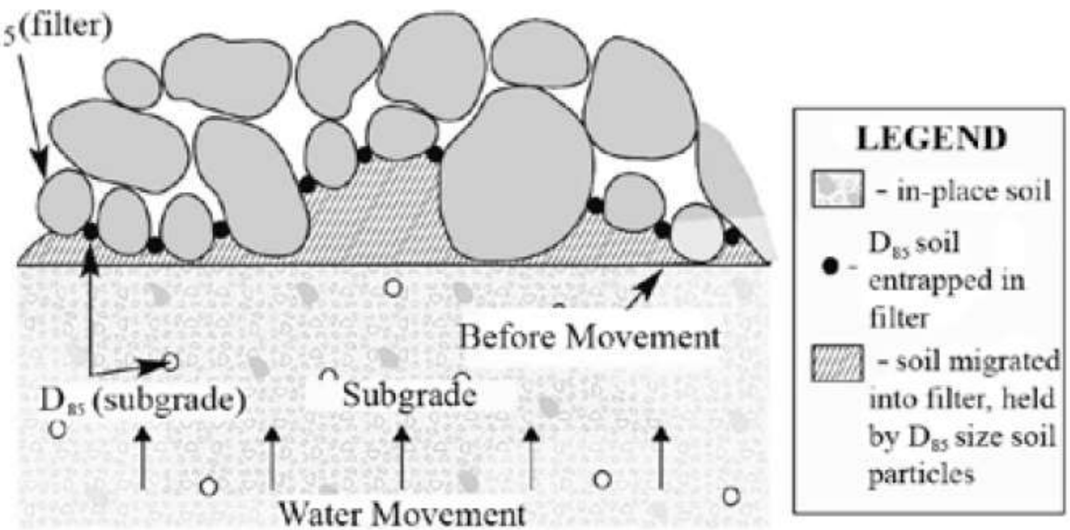
Particle Size Ratio Fundamental to Piping Concept



Spherical particle "B" will just pass through pore space between three spheres "A" 6 1/2 times the diameter of "B".

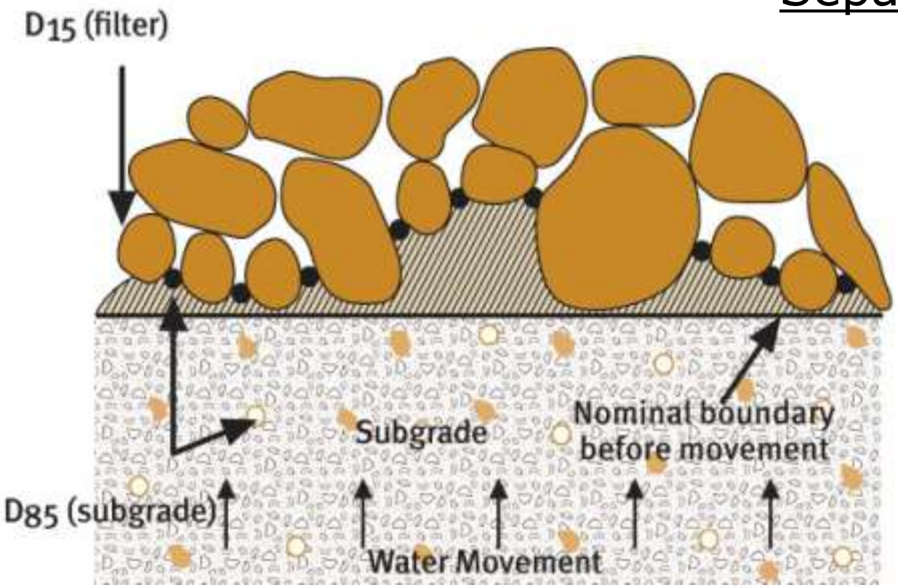
This size ratio is approximately that of a pea to billard balls.

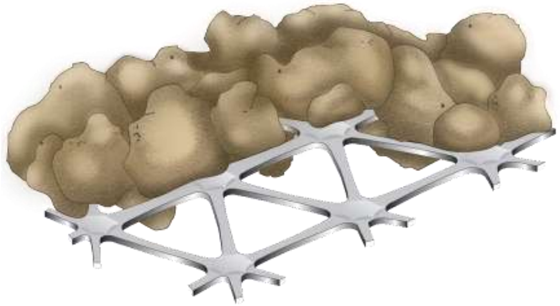
Preventing Piping with Graded (Natural) Filters



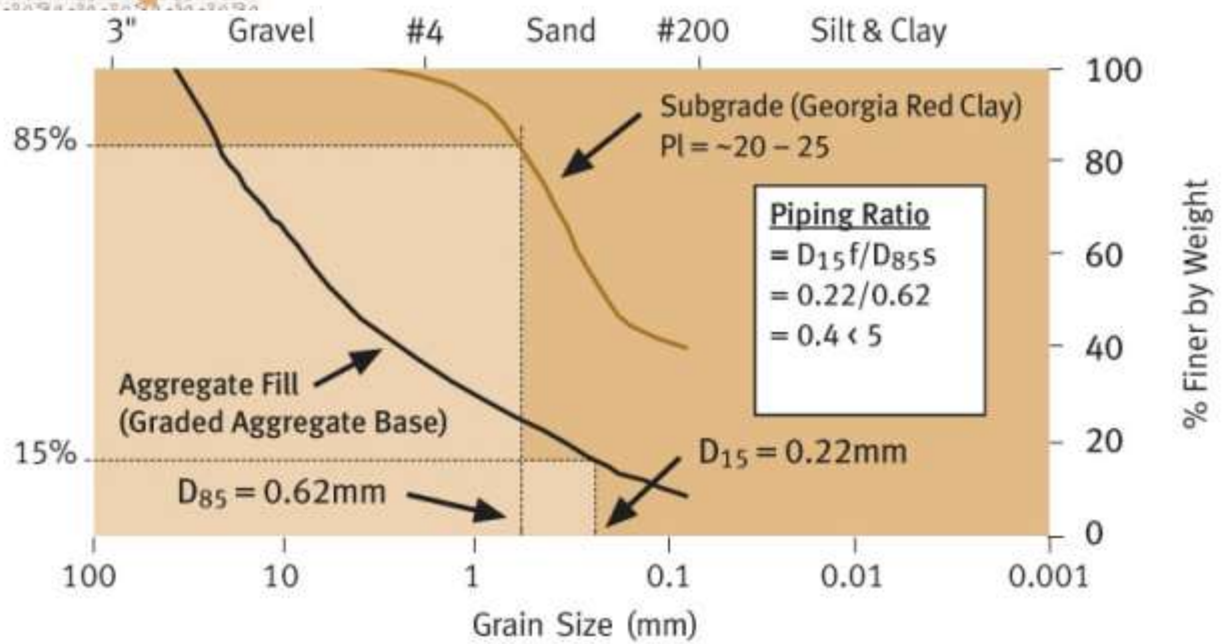
Function and Performance Mechanisms
Geogrids

Separation





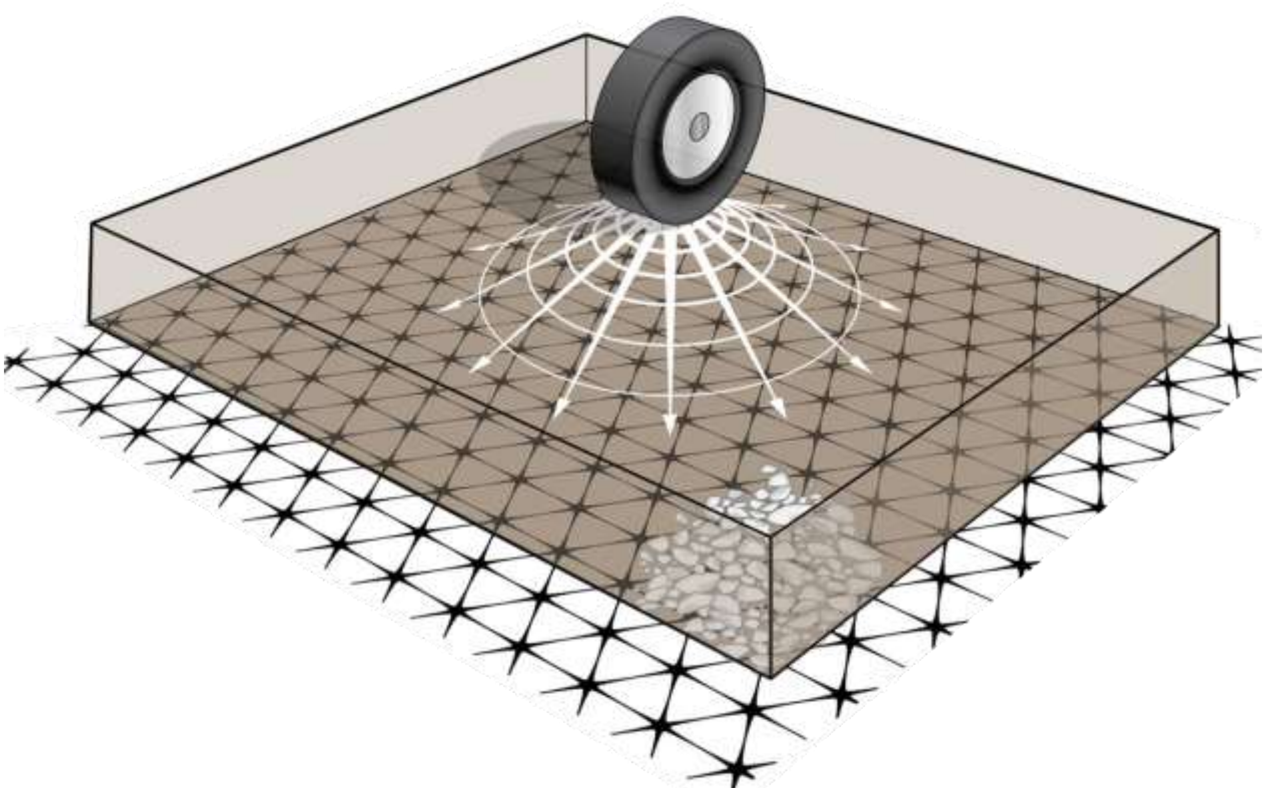
Piping Ratio Calculation



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:

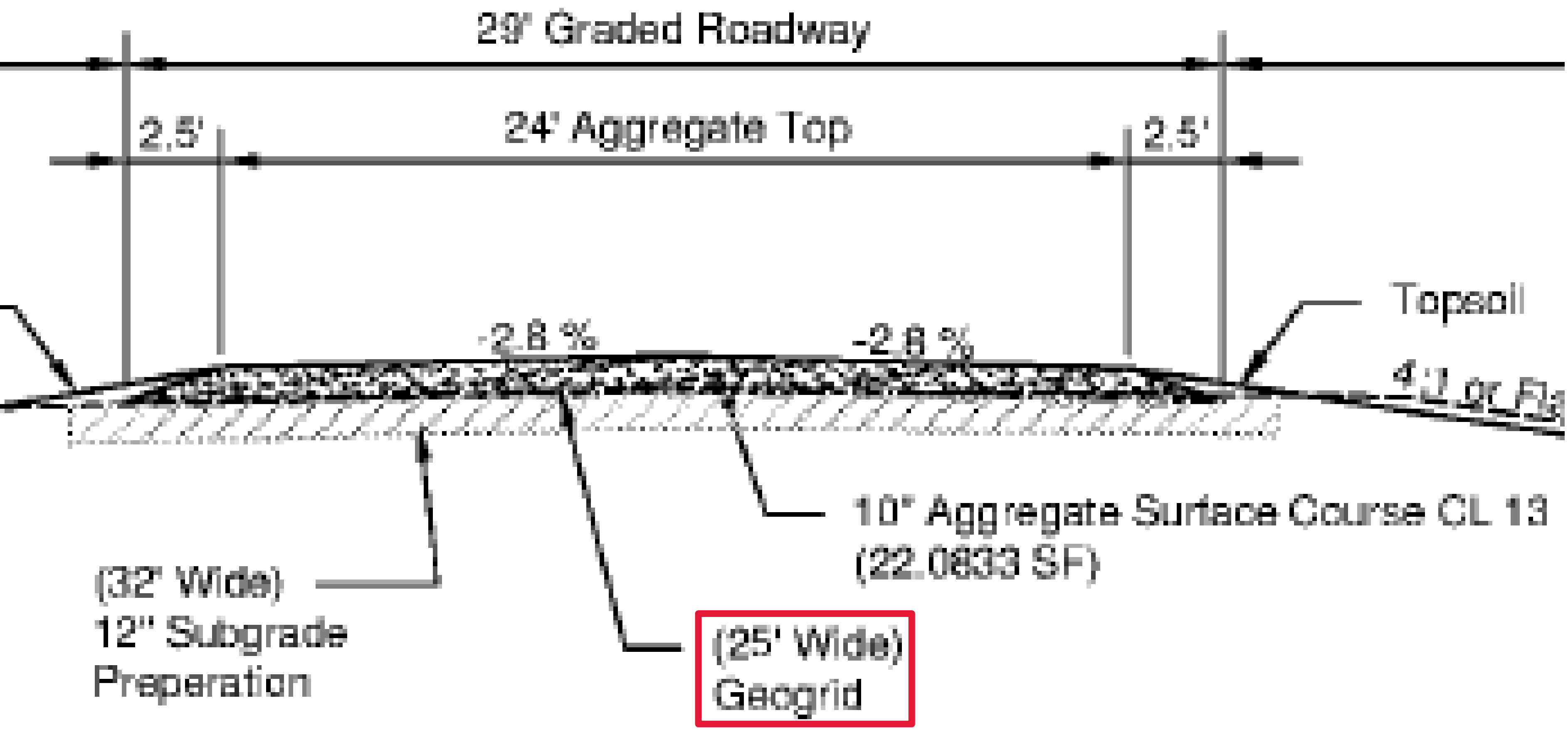
- Stiffen aggregate base
- Extend roadway life
- Prevent base failure

Roadway Applications

Unpaved road

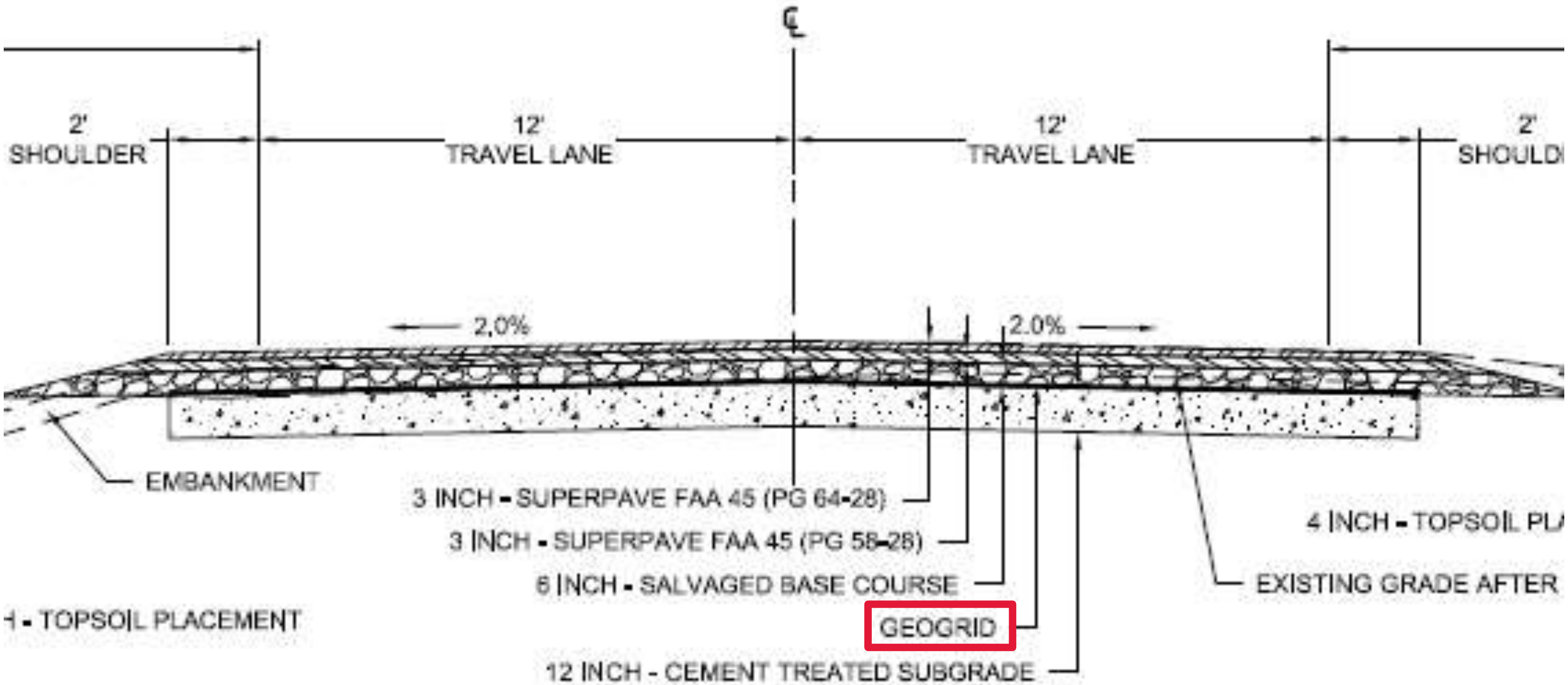
Roadway Applications

Unpaved road



PROPOSED TYPICAL

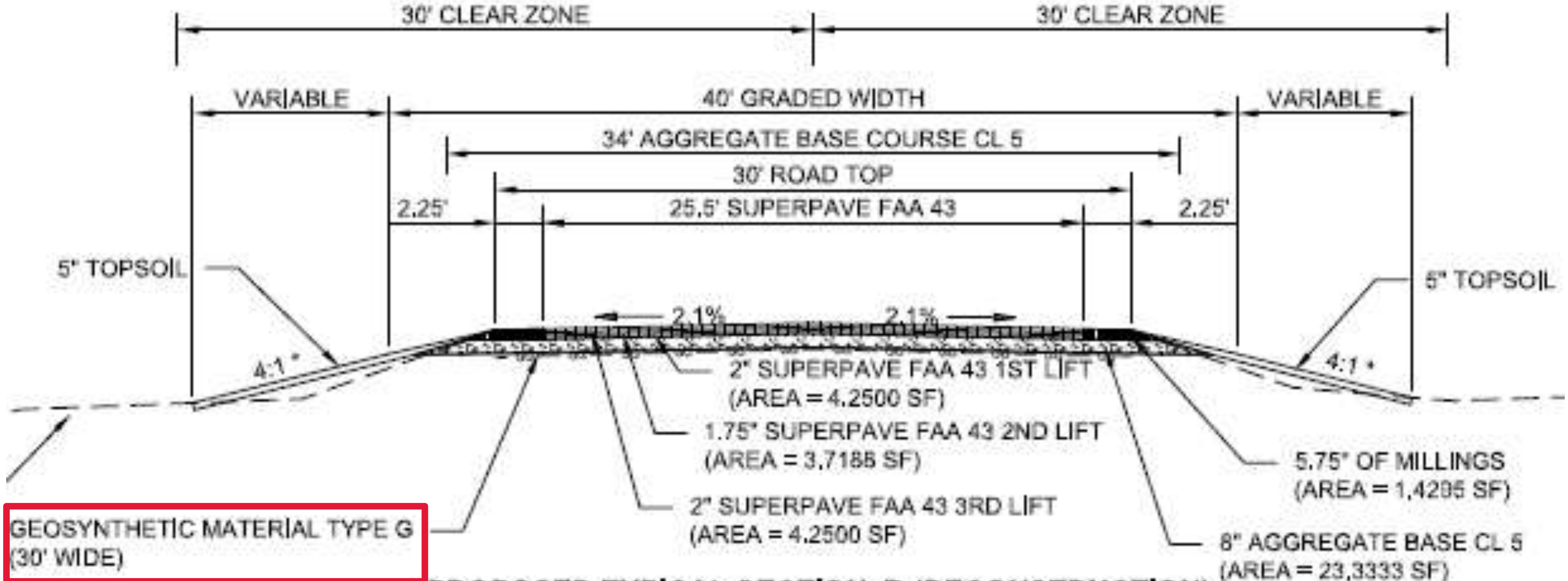
STA. 12+04 TO STA. 278+82



PROPOSED TYPICAL SECTION

SOUTH HEART RD

STA 14+75.55 TO 336+90.75
DESIGN SPEED 55 MPH

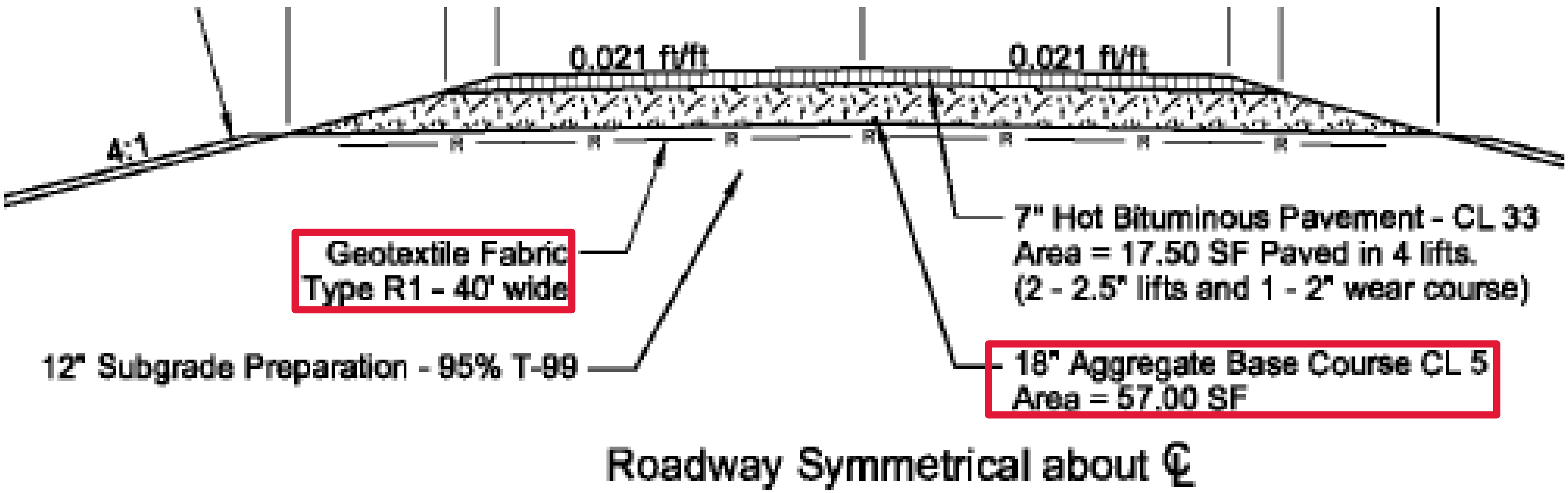


PROPOSED TYPICAL SECTION B (RECONSTRUCTION)

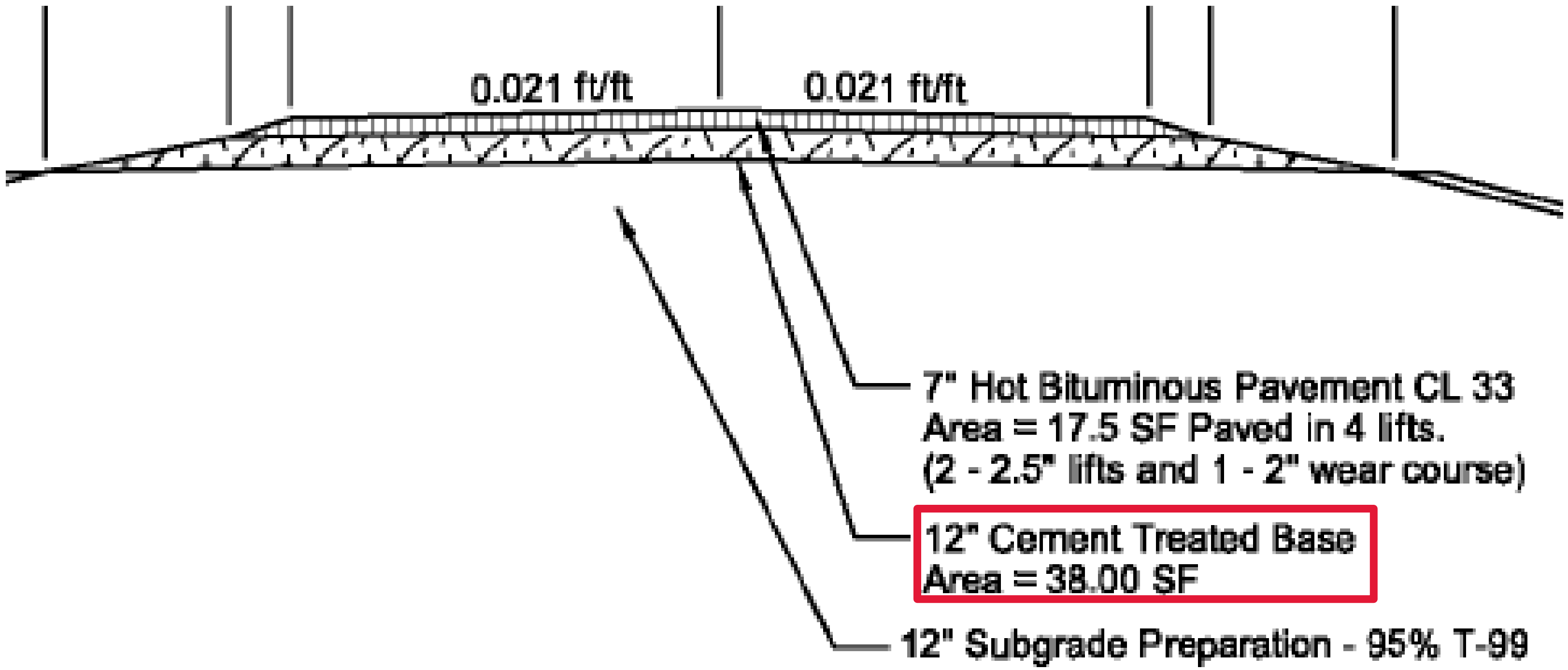
STA. 40+40 TO 47+70

STA. 48+33 TO 53+33

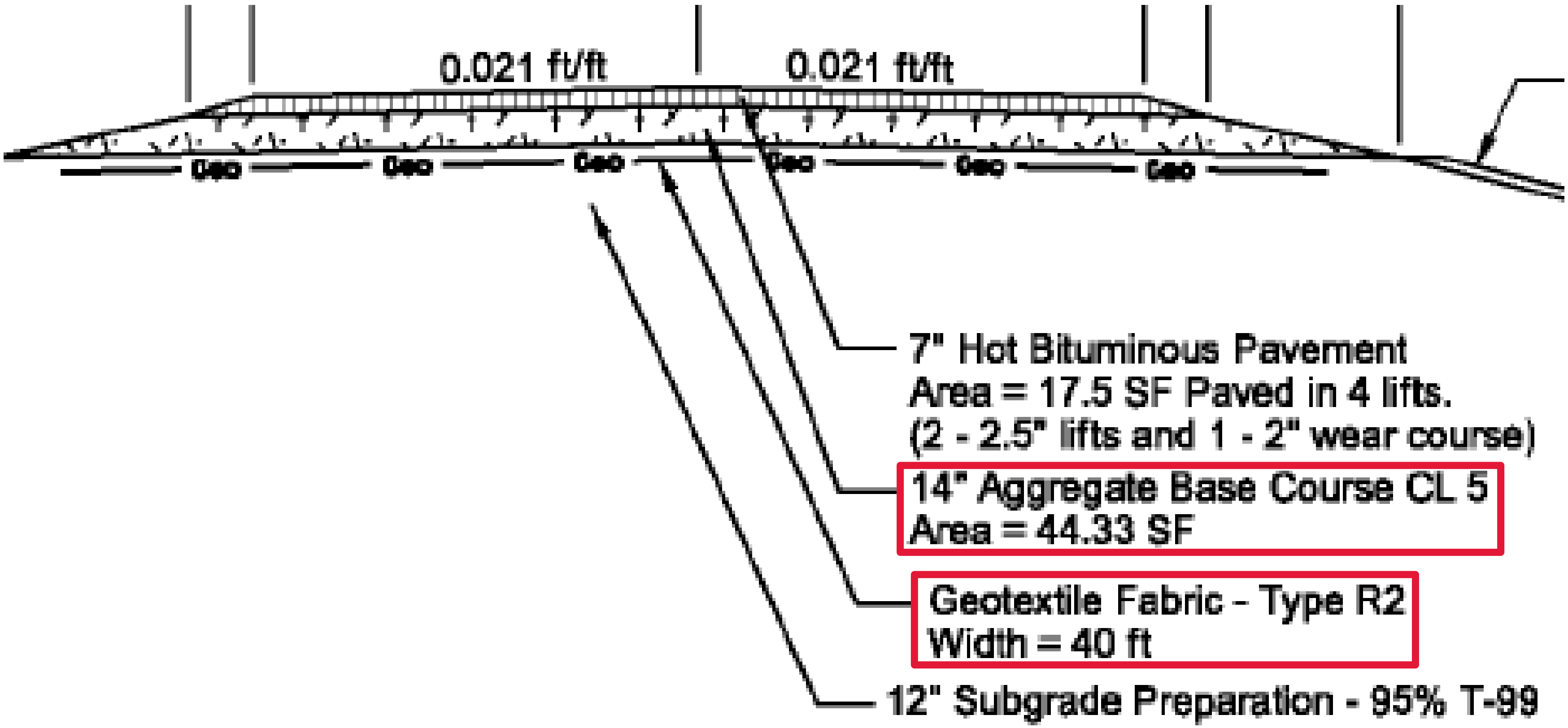
STA. 177+20 TO 186+25



0.021 ft/ft
0.021 ft/ft
4:1
R
Geotextile Fabric
Type R1 - 40' wide
12" Subgrade Preparation - 95% T-99
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
Roadway Symmetrical about ℄



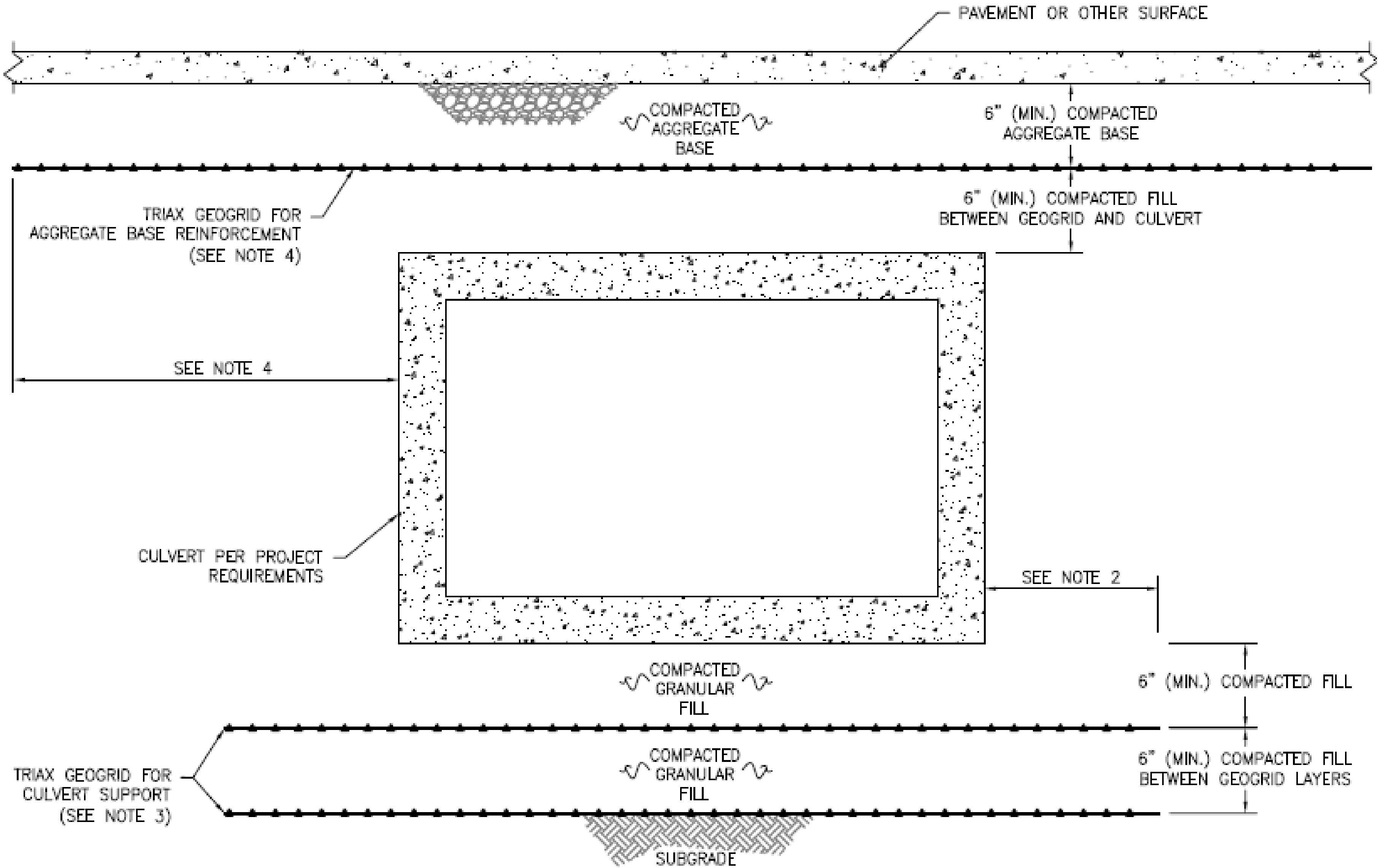
0.021 ft/ft
0.021 ft/ft
7" Hot Bituminous Pavement CL 33
Area = 17.5 SF Paved in 4 lifts.
(2 - 2.5" lifts and 1 - 2" wear course)
12" Cement Treated Base
Area = 38.00 SF
12" Subgrade Preparation - 95% T-99



0.021 ft/ft
0.021 ft/ft
Geo
Geo
Geo
Geo
Geo
Geo
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

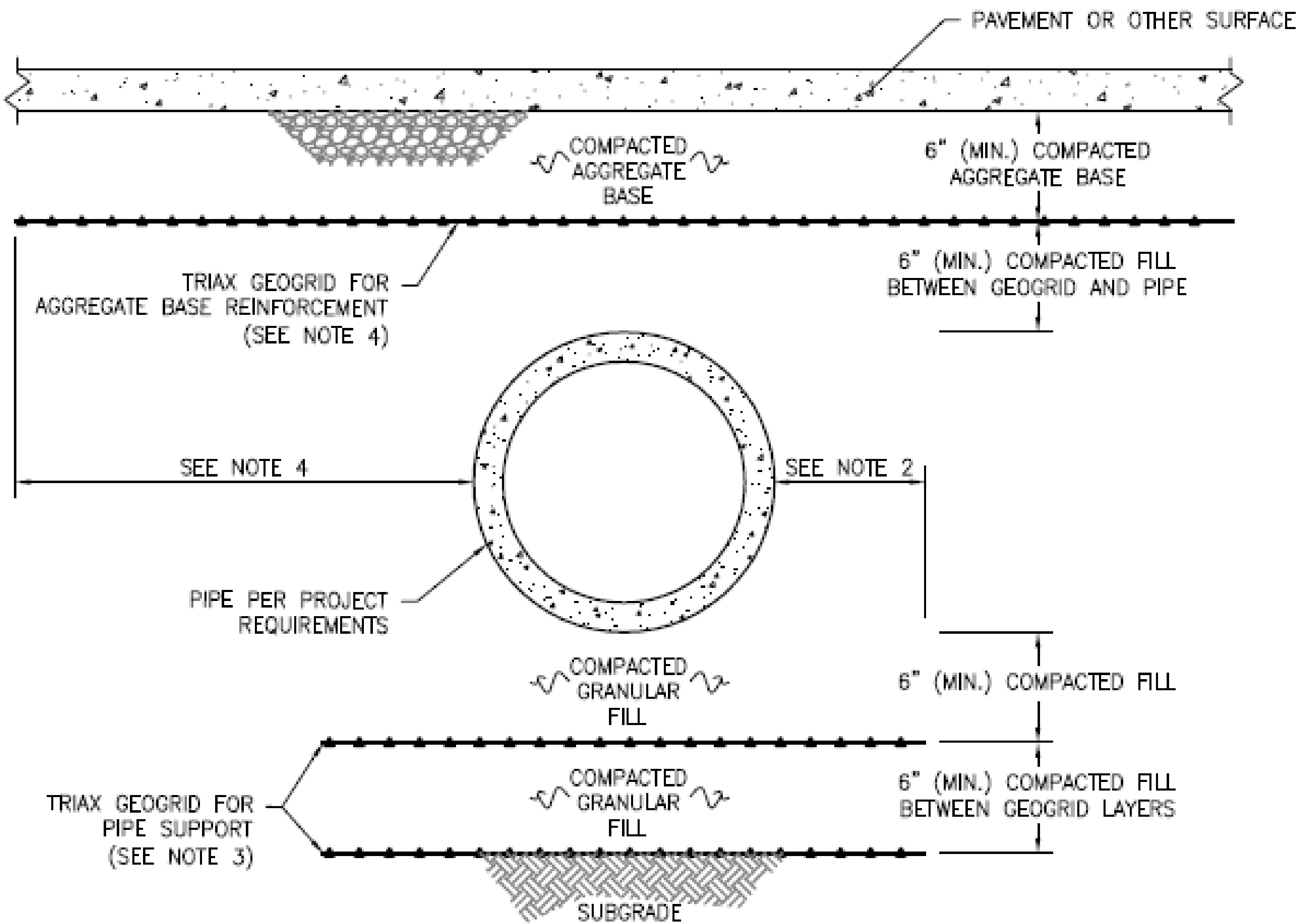
Roadway Applications

Structure & utility support



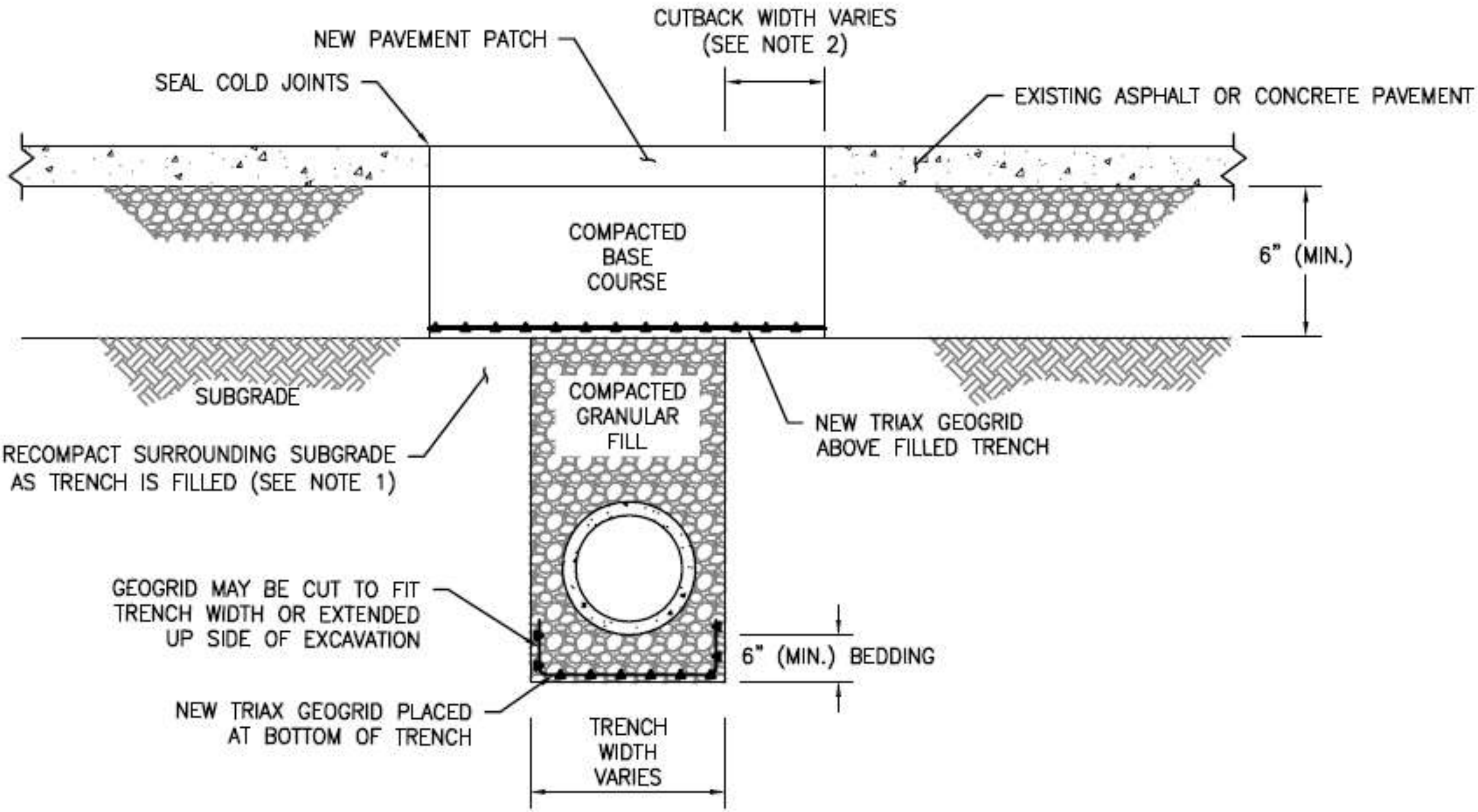
Roadway Applications

Structure & utility support



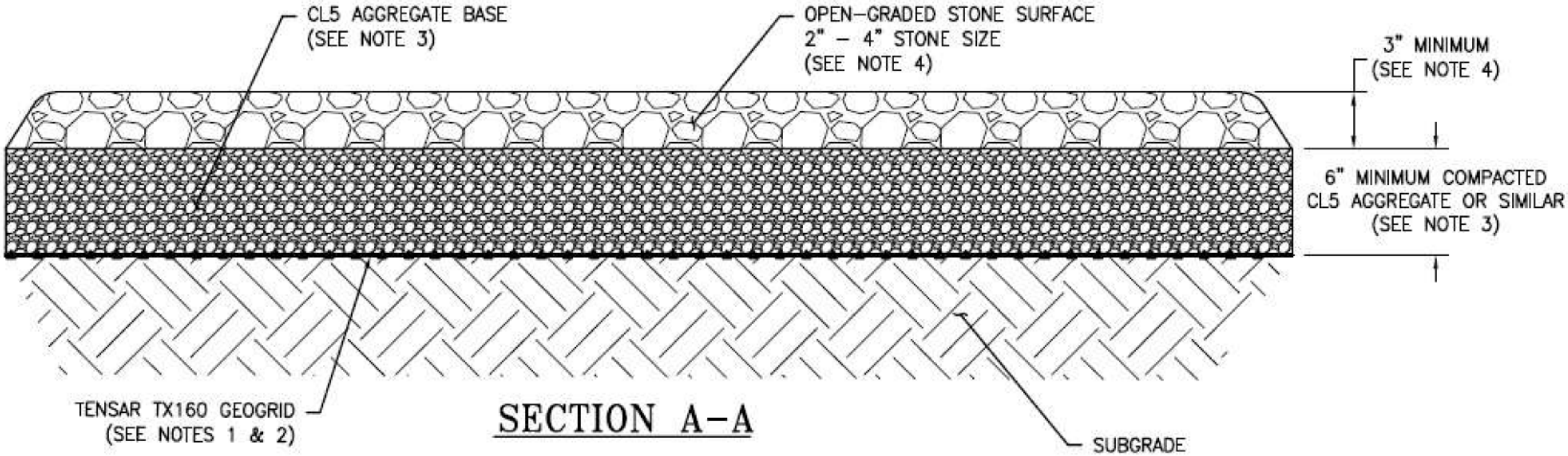
Roadway Applications

Structure & utility support



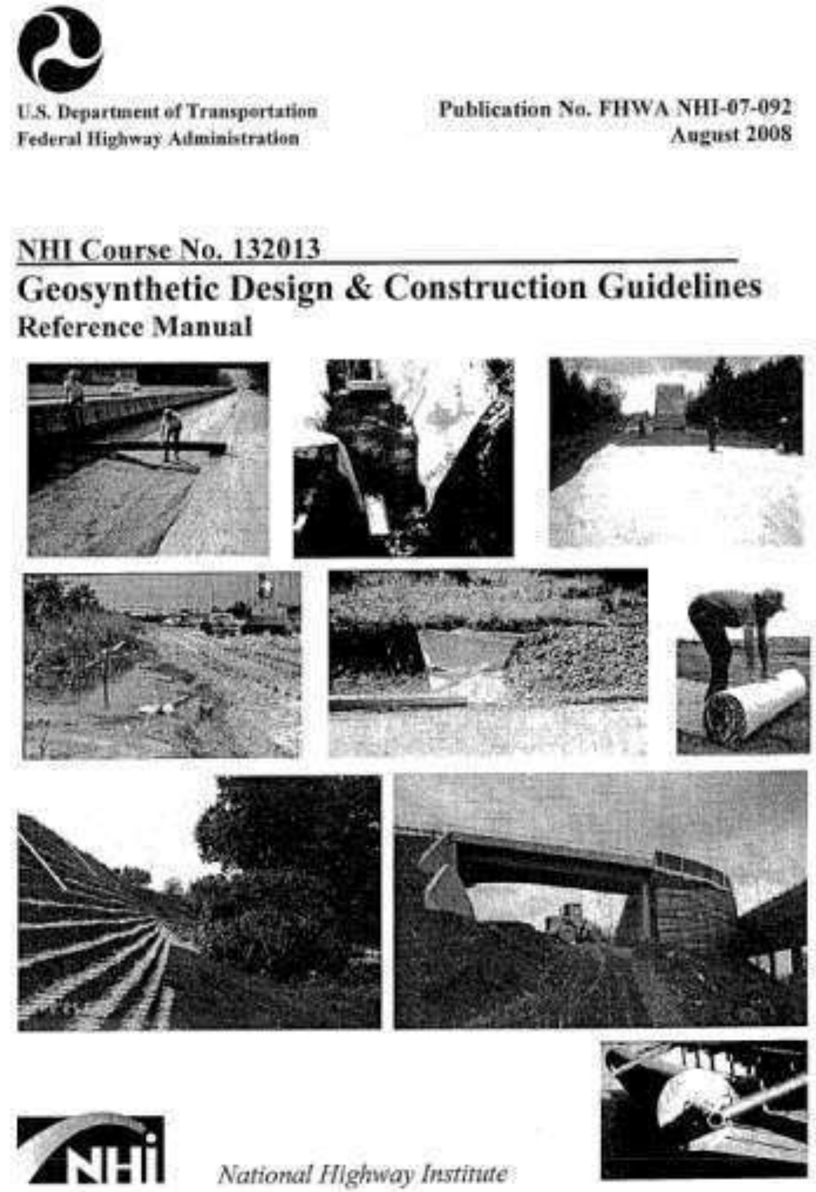
Roadway Applications

Construction Entrance



Tensar

Guidance Documents



Guidance Documents

Standard Practice for

Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures

AASHTO Designation: R 50-09[1]

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*:

- Geosynthetics Materials Association (GMA) White Paper I—"Geosynthetics in Pavement Systems Applications," May 1999. Available at bookstore@ifai.com.
- Geosynthetic Materials Association (GMA) White Paper II—"Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures," June 2000. Available at bookstore@ifai.com.
- National Highway Institute (NHI) Participant Notebook—*Geosynthetic Design and Construction Guidelines*, April 1999. Available at www.nhi.fhwa.dot.gov.

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

Guidance Documents

"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."

USACE–ETL1110-1-189
Aggregate Surfaced Roads

Table 5
Reinforced Bearing Capacity Factors, N_c[1], for Aggregate-Surfaced Pavements

Step 1: Determine Design Subgrade Soil Strength and Geosynthetic Applicability

CBR $\leq$ 0.5	**0.5 < CBR $\leq$ 2.0**			**2.0 < CBR $\leq$ 4.0**			**CBR > 4.0**
Use a geotextile and a geogrid at subgrade-base interface. No aggregate thickness reduction recommended. Use TM 5-822-12 for thickness design	Both a geogrid and a geotextile are recommended. Use this design procedure for aggregate thickness reduction.			A geotextile is required for fine-grained subgrades. A geogrid may also be cost-effective. Perform a life cycle cost analysis.			Perform a cost analysis. Consider "hidden" benefits. Inadequate data is available to determine bearing
	Geotextile	Geogrid	Both[2]	Geotextile	Geogrid	Both	
	5.0[3]	5.8	5.8	5.0[3]	5.8	5.8	

[1]The unreinforced bearing capacity factor, N_c, is 2.8.
[2]Both a geotextile and a geogrid are recommended. The geotextile serves primarily as a separation fabric.
[3]Use a factor of 3.6 for conservative geotextile-reinforced pavement designs.

USACE–ETL1110-1-189
Aggregate Surfaced Roads

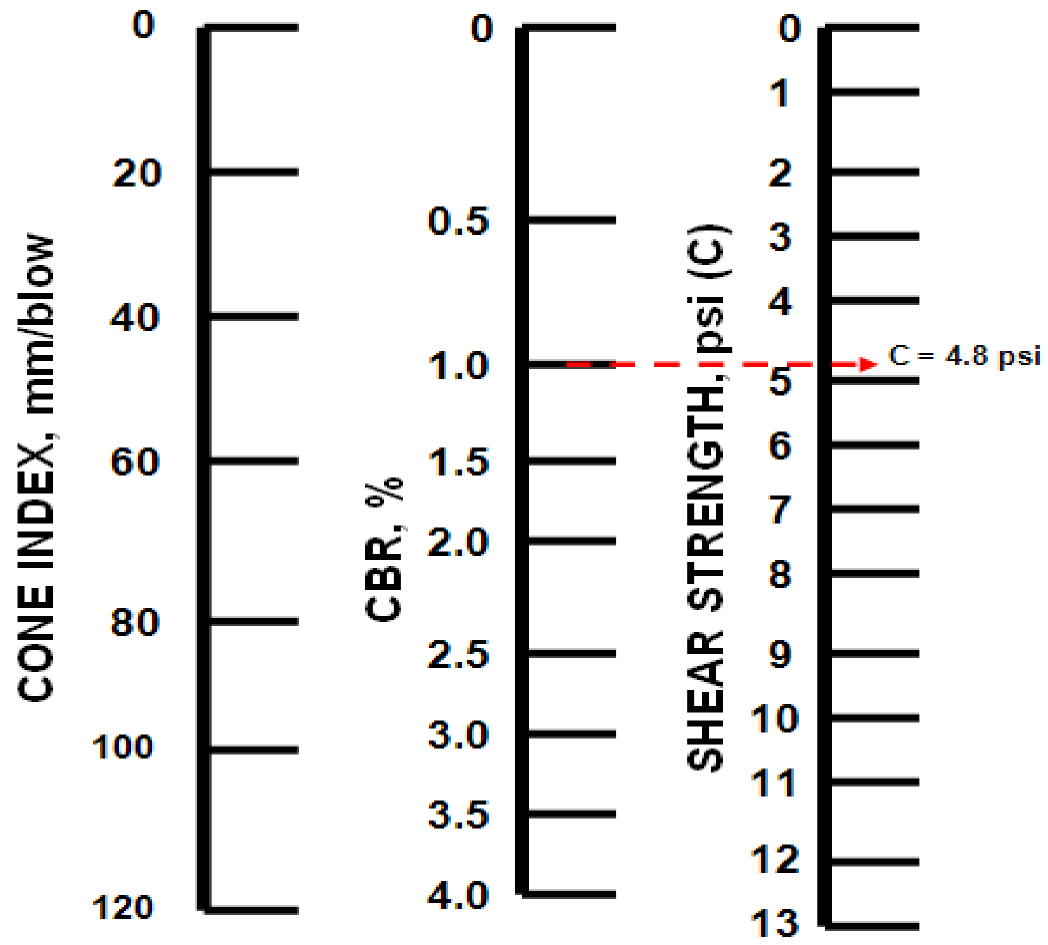
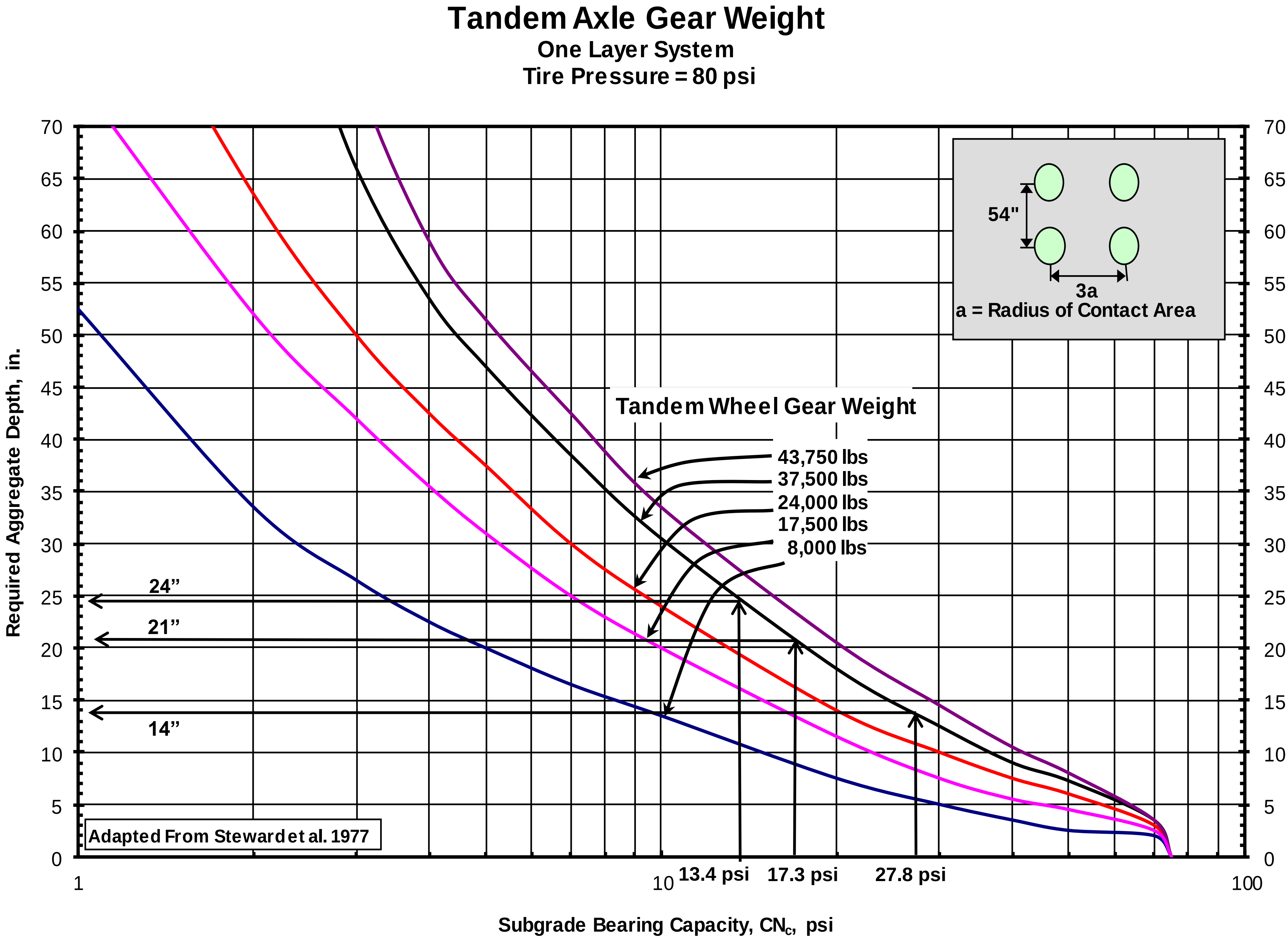


Figure 4 – Relationship between cone index, CBR, and shear strength (p. 7)



Tandem Axle Gear Weight
One Layer System
Tire Pressure = 80 psi
Required Aggregate Depth, in.
Subgrade Bearing Capacity, CNc, psi
54"
3a
a = Radius of Contact Area
Tandem Wheel Gear Weight
43,750 lbs
37,500 lbs
24,000 lbs
17,500 lbs
8,000 lbs
24"
21"
14"
13.4 psi
17.3 psi
27.8 psi
Adapted From Steward et al. 1977

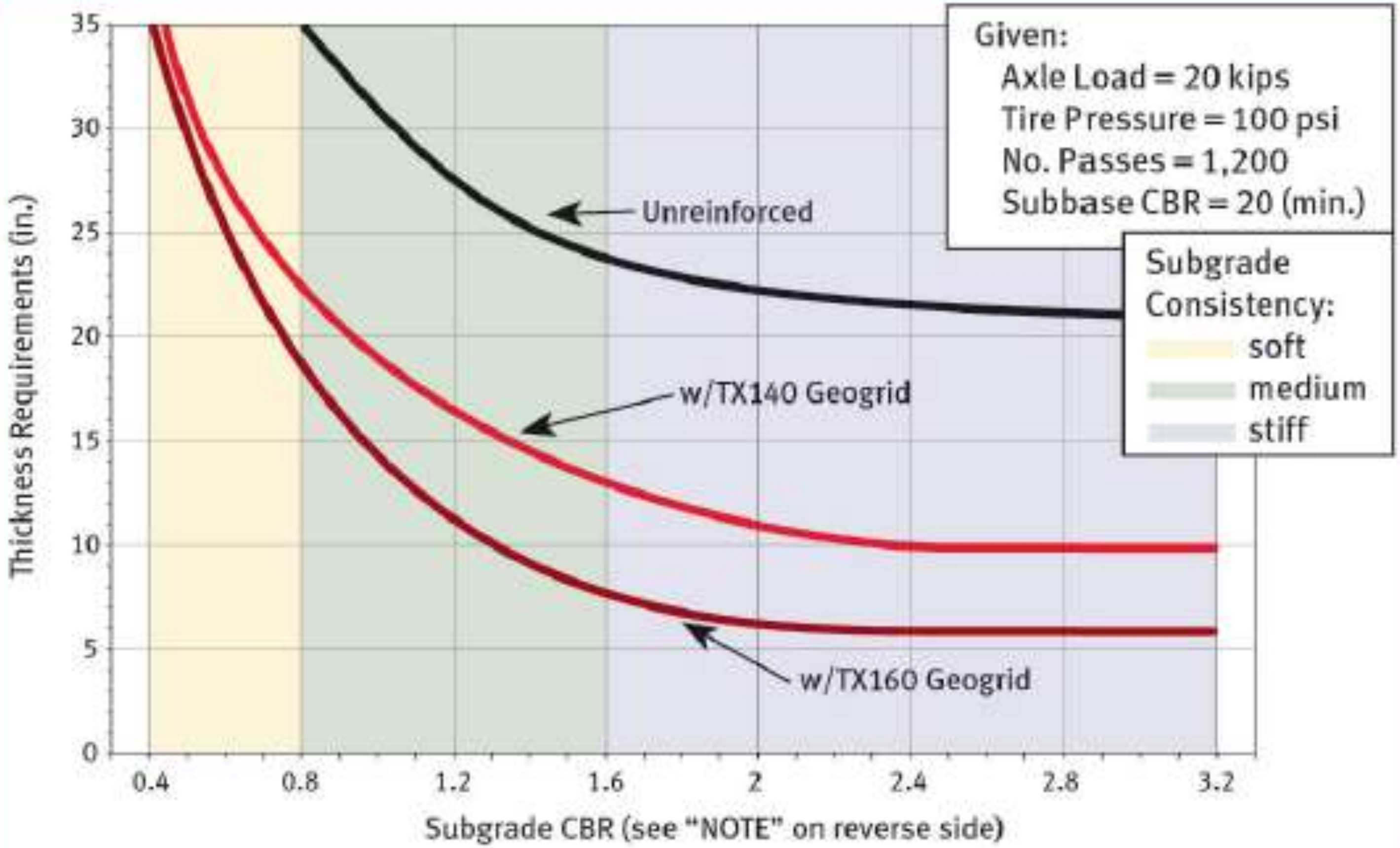
Tensar SpectraPave Software

TriAx Pocket Card

Tensar

Aggregate Thickness Requirements for a Typical Unpaved Applications Scenario

Rut Depth = 1½ Inches



TriAx Pocket Card

Guide for Estimating Subgrade Soil Strengths (Fine-Grained Soils)

Estimated Consistency by:		Test by:				Correlates to:				
		Standard Penetration Test (blows/ft)	Dynamic Cone Penetrometer			Shear Strength, C_u		California R Value	R Value	CBR
Feel	Equipment/Visual		SC, SM, SP	CL	CH	(psi)	(tsf)			
Very Soft	Man standing sinks > 3 inches	< 2	—	—	—	< 1.7	< 0.125	< 5	—	< 0.4
Soft	Man walking sinks ~ 2 - 3 inches	2 - 4	—	—	—	1.7 - 3.5	0.125 - 0.25	< 5	< 0.36	0.4 - 0.8
Medium	Man walking sinks ~ 1 inch	4 - 8	—	> 2.6	—	3.5 - 6.9	0.25 - 0.50	< 5	0.36 - 2.5	0.8 - 1.6
Stiff	Pickup truck ruts ~ 1/2 - 1 inch	8 - 15	> 3.9	2.6 - 1.8	—	6.9 - 13.9	0.50 - 1.0	5 - 20	2.5 - 6.8	1.6 - 3.2
Very Stiff	Loaded dump truck ruts ~ 1 - 3 inches	15 - 30	3.9 - 2.2	1.8 - 1.3	> 4.3	13.9 - 27.8	1.0 - 2.0	20 - 33	6.8 - 15.5	3.2 - 6.4
Hard	Insignificant ruts from loaded dump truck	> 30	2.2 - 1.1	1.3 - 0.9	4.3 - 2.1	> 27.8	> 2.0	> 33	> 15.5	> 6.4

Field Test Section

DCP Test

DCP TEST DATA

Project: ____________________ Date: ____________________

Location: ____________________ Soil Type(s): High plasticity Clay

Hammer
- ○ 10.1 lbs.
- ● 17.6 lbs.
- ○ Both hammers used

Soil Type
- ● CH
- ○ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
1	30	1
1	100	1
1	180	1
1	270	1
1	400	1
2	600	1
2	750	1
		1
		1
		1
		1
		1
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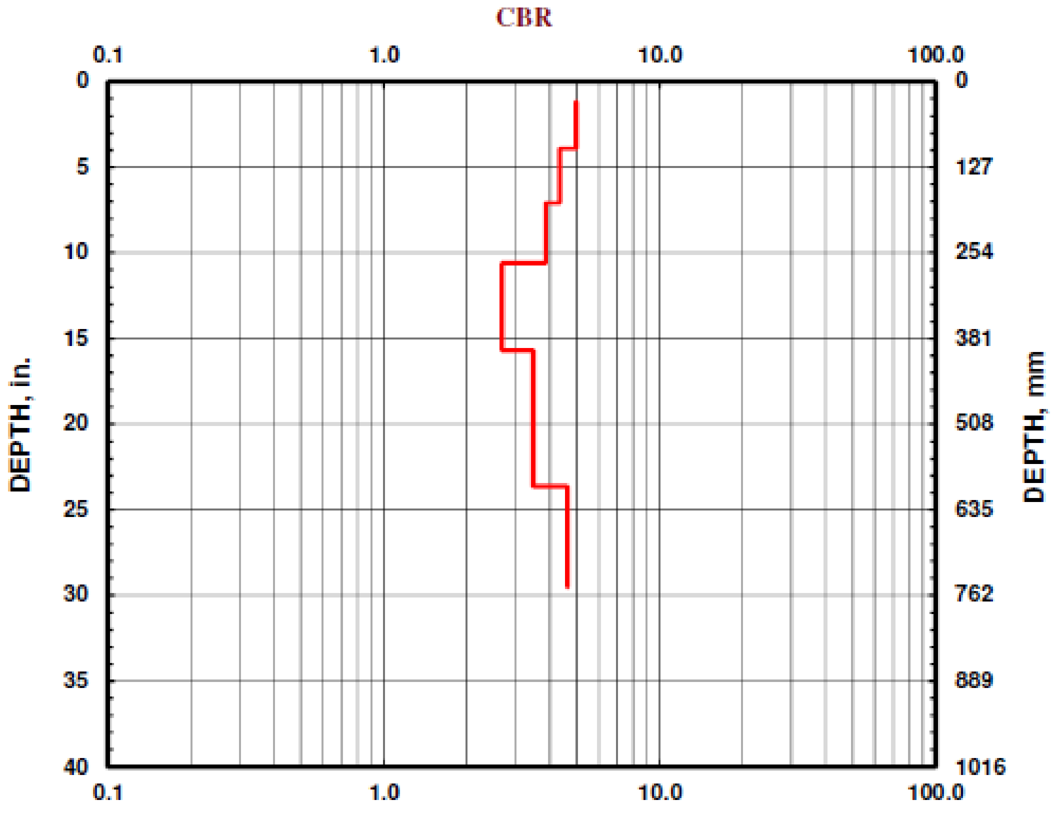
		1
		1



NDDOT 2014 Specs – Geogrid

Tensar

SECTION 709
GEOSYNTHETICS

709.01 DESCRIPTION
This work consists of furnishing and installing geosynthetics.

709.02 EQUIPMENT
Reserved.

709.03 MATERIALS

Item	Section
Geosynthetics	858

C. Geosynthetic Geogrid (Type G).

Table 858-03
Geogrid Geosynthetics

GEOGRID PROPERTY	TEST METHOD	GEOGRID TYPE G
Aperture Size	ID Calipered	0.5 - 1.5 inch
Tensile Strength[1] @ 2% Strain, lb/ft, min.	ASTM D 6637	400
Tensile Strength[1] @ 5 % Strain, lb/ft, min	ASTM D 6637	800
Ultimate Tensile[1] Strength, lb/ft, min.	ASTM D 6637	1,300

Table 858-03
Geogrid Geosynthetics

GEOGRID PROPERTY	TEST METHOD	GEOGRID TYPE G
Junction Strength, lb, min.	GRI[2] GG2	25
UV Resistance (After 500 hrs), % Strength Retained	ASTM D 4355	70

[1] Strength values represent weakest principal direction
[2] Geosynthetic Research Institute

NDDOT 2014 Specs – Geogrid

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.

INSTALLATION GUIDE

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

Geogrid Overlaps

Summary of Tensar® TriAx® Geogrid Installation Parameters						
Subgrade Strength	Clear All Vegetation?	Geogrid Orientation[3]	Geogrid Overlap[4]	Nylon Zip Ties?[1,2]	Direct Traffic?[5]	Geotextile?[6]
CBR ≤ 0.5	N	T or L	3 ft	Y	N	Analysis Req'd
0.5 ≤ CBR ≤ 2	Usually	L	2-3 ft	N	N	Analysis Req'd
2 ≤ CBR ≤ 4	Y	L	1-2 ft	N	Limited	Analysis Req'd
4 ≤ CBR	Y	L	1 ft	N	N	N

NOTES:

1. Summary is a generalized presentation; see text for specifics.

2. Y = Yes, normally required; N = No, not normally required.

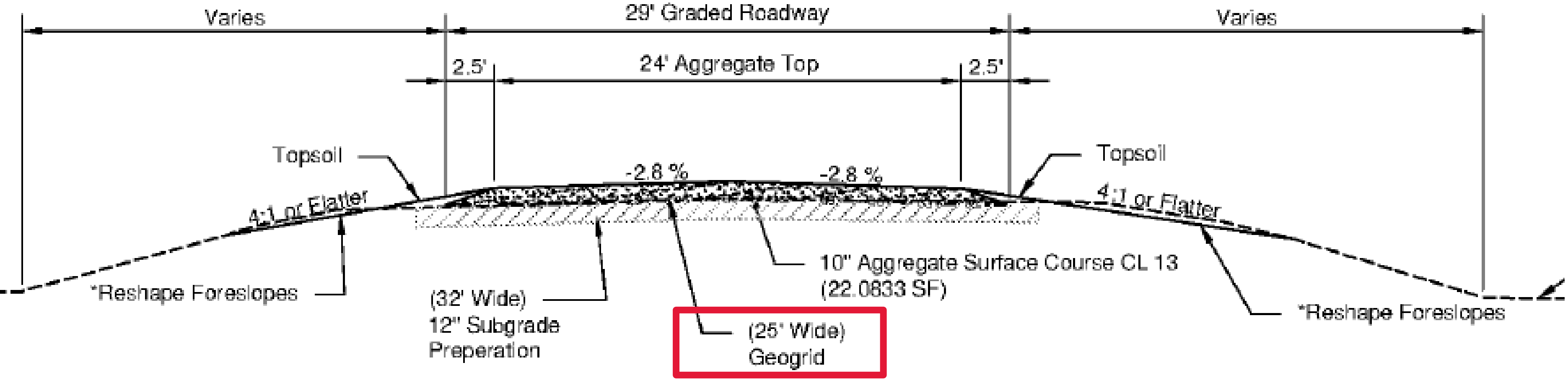
3. Geogrid Orientation (roll axis in relation to traffic): T = Transverse, L = Longitudinal.

4. General Geogrid Overlap Rule: Overlap = 3 ft for CBR ≤ 1; Overlap = 1 ft for CBR ≥ 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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Spreading Aggregate

Spreading Aggregate

Tensar

BROCK WHITE
CONSTRUCTION MATERIALS

- *Bismarck*
- *Fargo*
- *Minot*