Tensar®

Geogrid Applications

Presented to:

ASCE FLORIDA SECTION Palm Beach Branch

March 8, 2022

Welcome & Introductions

Andres F. Peralta, P.E.
Associate Regional Sales
Manager South Florida

George Charalambous, P.E.
Senior Regional Sales Manager
Florida & Coastal Georgia

Scan to Access
Sign-In Sheet

Tensar

Welcome & Introductions

Scan to Access Sign-In Sheet

Agenda

- Tensar Overview
- Geogrid Mechanics
- Subgrade Stabilization & Design Example
- Pavement Optimization & Design Example
- Additional Tensar Geogrid Applications
- Local Projects in Florida

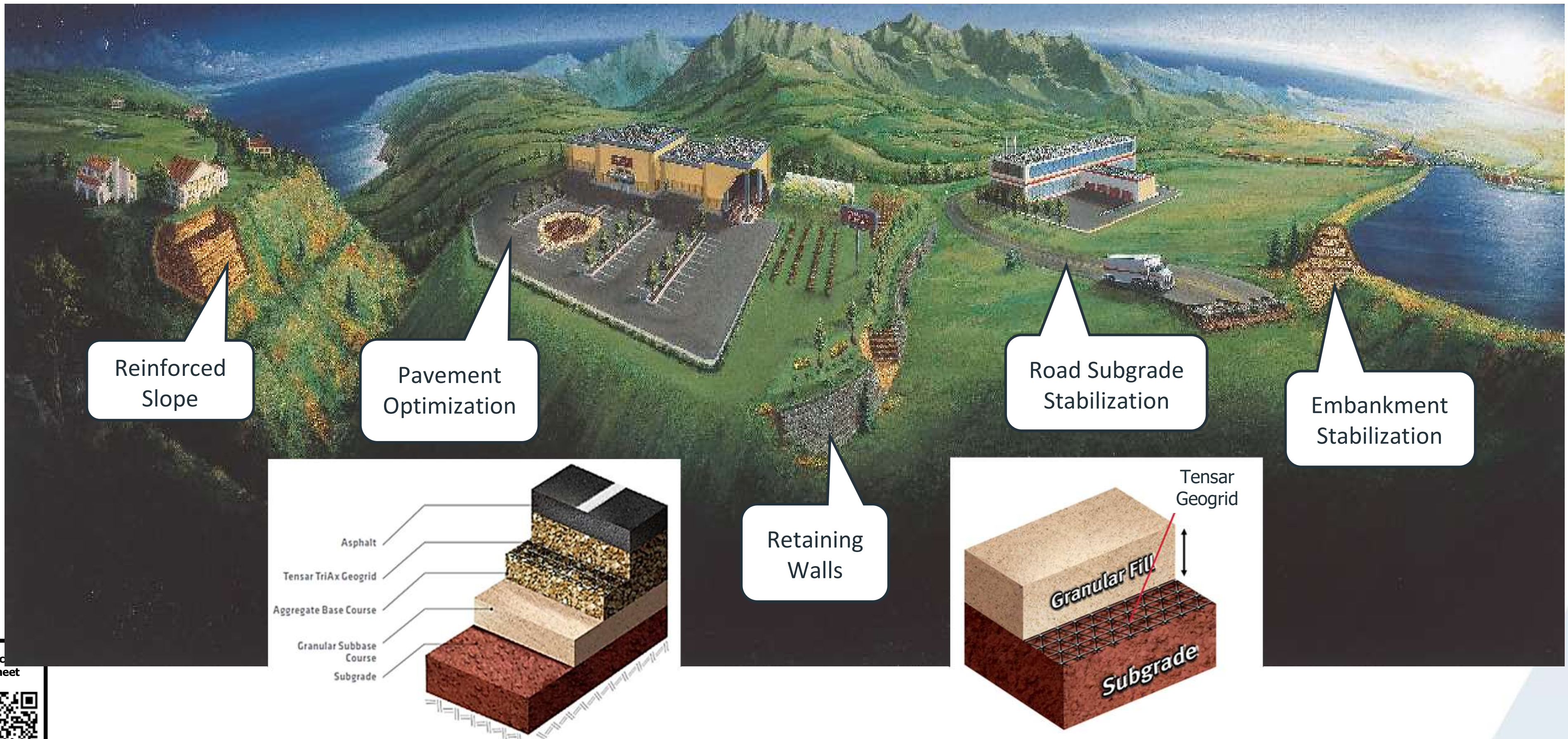
Scan to Access
Sign-In Sheet

Who is Tensar?

- Tensar is a geogrid manufacturer and the inventor of geogrid. We provide engineered solutions for civil engineering applications using our products.
- We help engineers, contractors and owners use geogrid to achieve more cost-effective, reliable solutions for pavement construction, soil stabilization, earth reinforcement, and other site development challenges.
- Our products are backed by extensive research and significant field experience, and we have a highly qualified team of professional engineers ready to support our solutions.
- 330 patents worldwide & 1.2 billion SY of product installed to date.

Scan to Access Sign-In Sheet

Who is Tensar?



Scan to Acc
Sign-In Sheet

What are Geogrids?

Scan to Access
Sign-In Sheet

Tensar

What are geosynthetics?

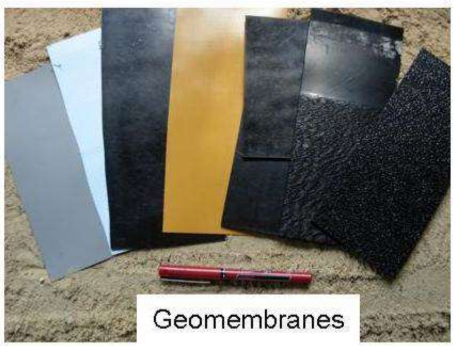
- Definition: *planar products manufactured from polymeric materials used with soil, rock, earth or other geotechnical engineering related materials as an integral part of human-made project, structure, or system*[1].

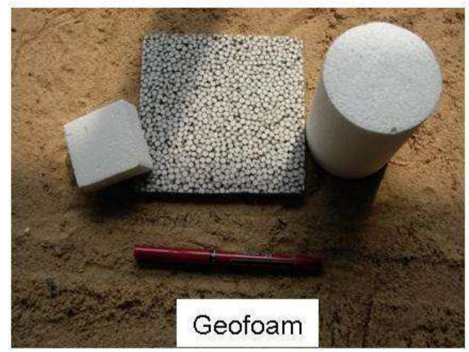
- Polymeric man-made construction materials used to enhance the engineering properties of soil and granular media.

Scan to Access
Sign-In Sheet

1. Koerner, R. M. (2012). *Designing With Geosynthetics* (6th ed.). Xlibris Publishing Co., 914 pgs.

Types of geosynthetics

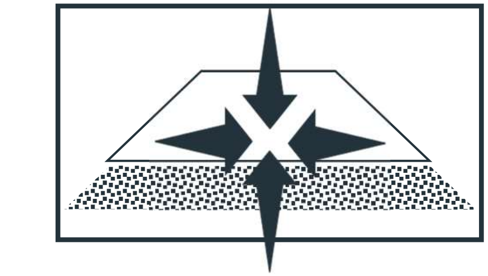




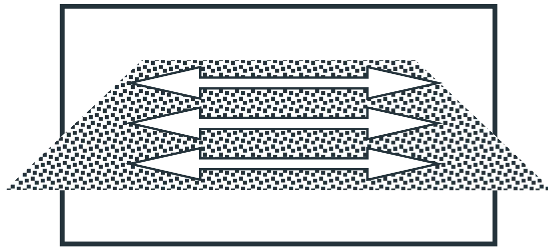
Koerner, R. M. (2012). *Designing With Geosynthetics* (6th ed.). Xlibris Publishing Co., 914 pgs.

Scan to Access Sign-In Sheet

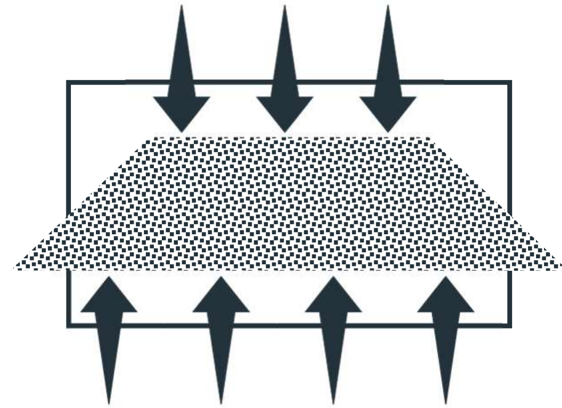
Geosynthetic functions



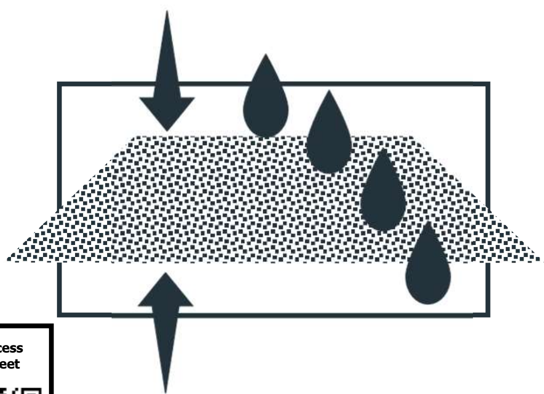
1. Stabilization



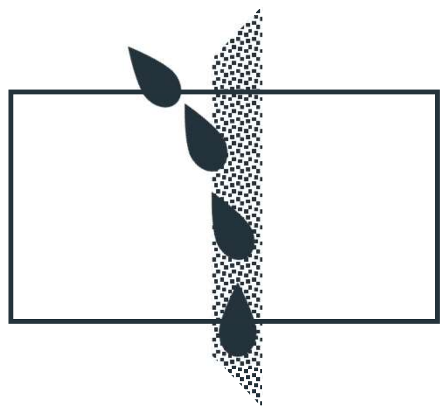
2. Reinforcement



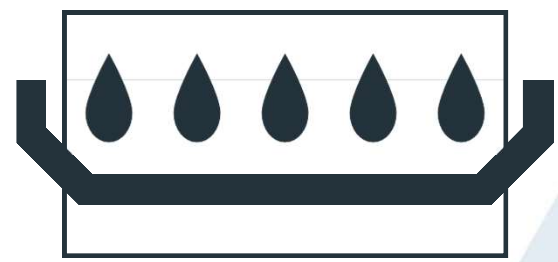
3. Separation



4. Filtration



5. Drainage

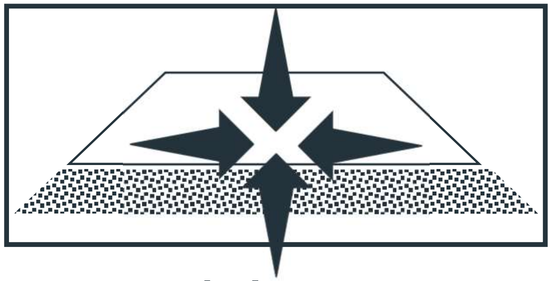


6. Containment

Geosynthetic Functions - Summary

Type of Geosynthetic Material	Stabilization	Reinforcement	Separation	Filtration	Drainage	Containment
Geogrid	X	X	X	X		
Geotextile		X	X	X	X	
Geocells	X					
Geocomposite		X	X	X	X	X
Geonet					X	
Geomembrane						X
Geosynthetic Clay Liner						X
Geofoam			X			

Multiaxial Geogrids for Stabilization Purposes

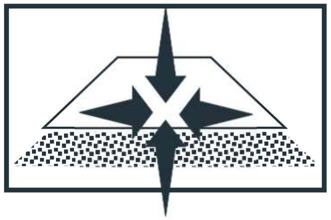


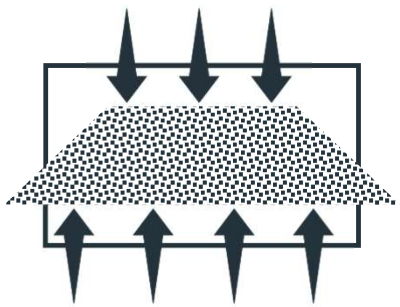
Stabilization

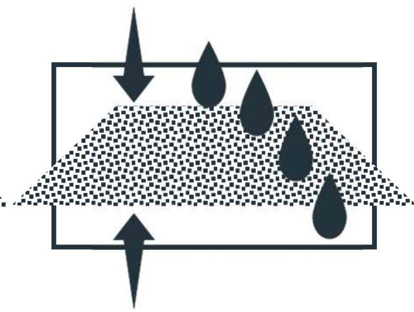
Scan to Access Sign-In Sheet

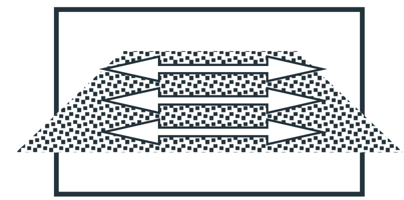
What are Geogrids?

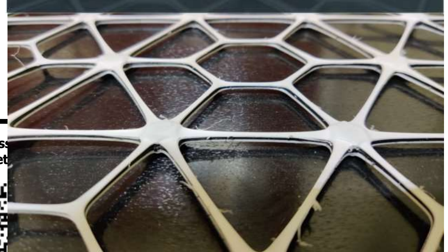
- Geogrids are used to provide the functions of:

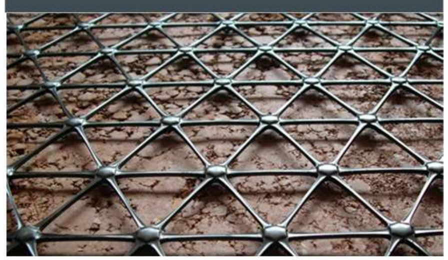

Stabilization

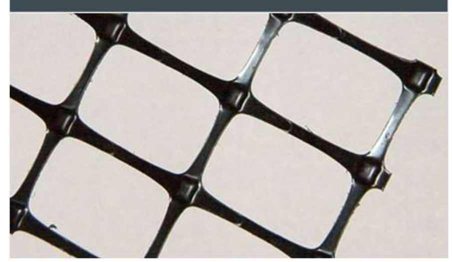

Separation


Filtration


Reinforcement

InterAx Geogrid (NX)


TriAx Geogrid (TX)


Biaxial Geogrid (BX)


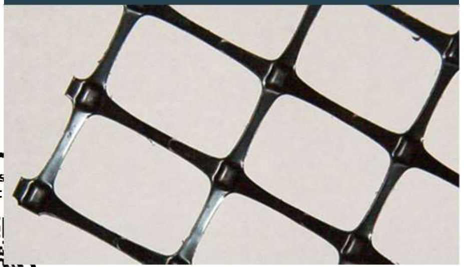
Uniaxial Geogrid (UX)


Stabilization Geogrids From Tensar

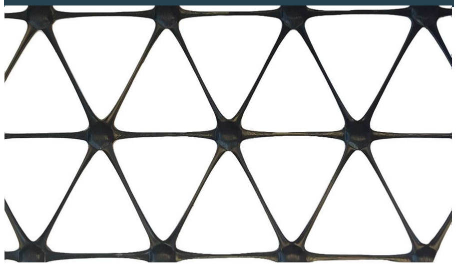
Geogrid Family

- Invented by Tensar in the late 1970s
- Biaxial geogrids have square or rectangular openings, called apertures

Biaxial (BX) Geogrid

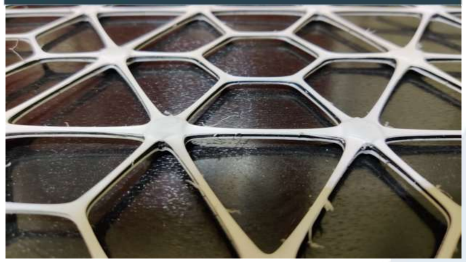


TriAx (TX) Geogrid



- Invented by Tensar approximately 15 years ago
- Diagonal ribs that increase the in-plane stiffness of the product in all directions
- The triangular apertures and hexagonal geometry improve traffic loading absorption and distribution
- High aspect ratio ribs provide better interlock with the surrounding aggregate

InterAx Geogrid (NX)

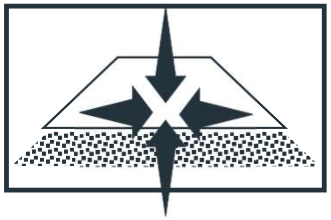


- Introduced to the market in 2021
- Optimized geometry to allow better confinement of a broader range of soil gradations
- Improved material structure: Coextrusion and interactive layer to improve soil interaction and allow better performance
- Optimized rib aspect ratio to allow better interlocking

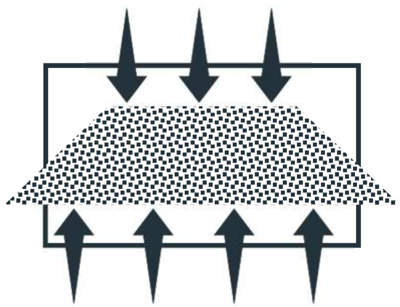
Scan to Access Sign-In Sheet

What are Geogrids?

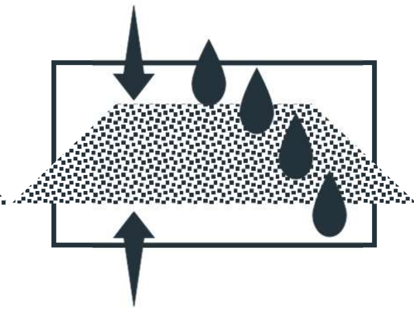
- Geogrids are used to provide the functions of:



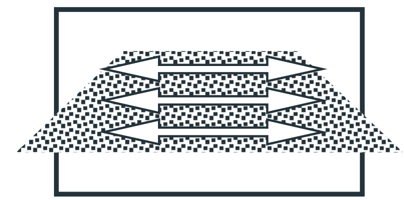
Stabilization



Separation

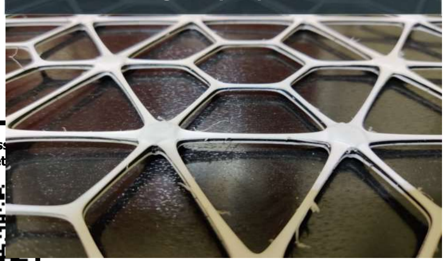


Filtration

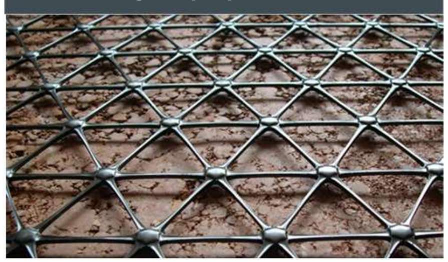


Reinforcement

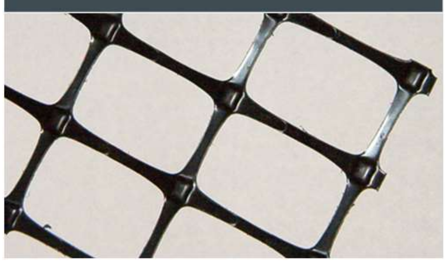
InterAx Geogrid (NX)



TriAx Geogrid (TX)



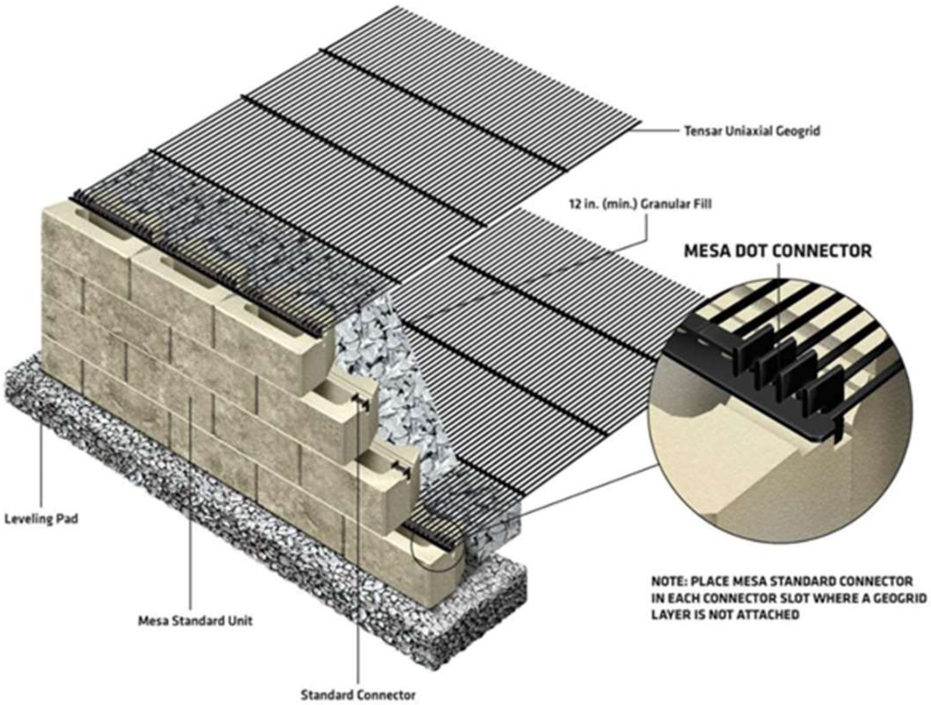
Biaxial Geogrid (BX)

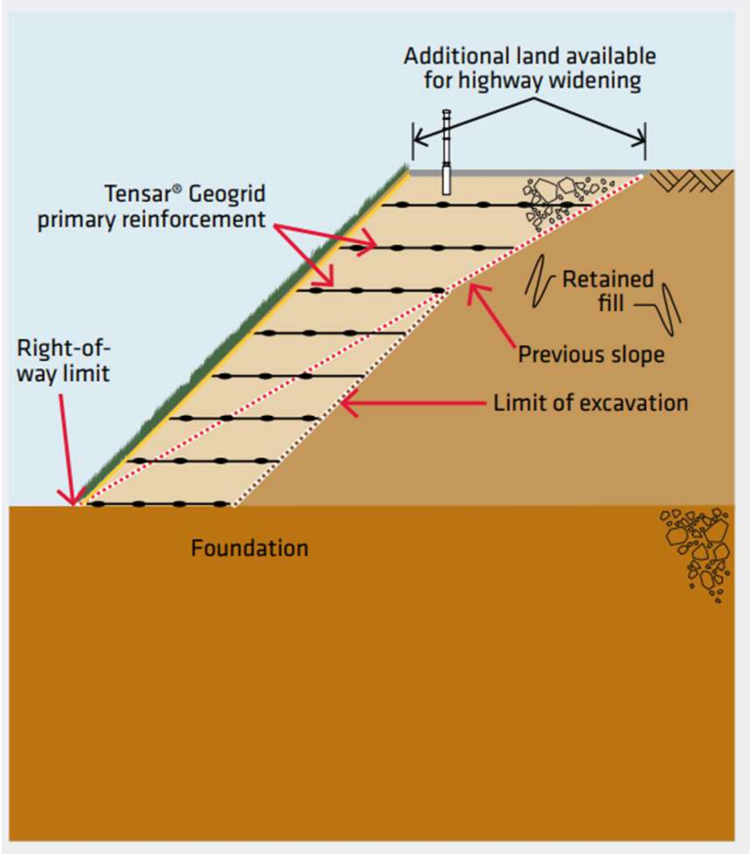


Uniaxial Geogrid (UX)

Reinforcement Geogrids From Tensar

Uniaxial Geogrids

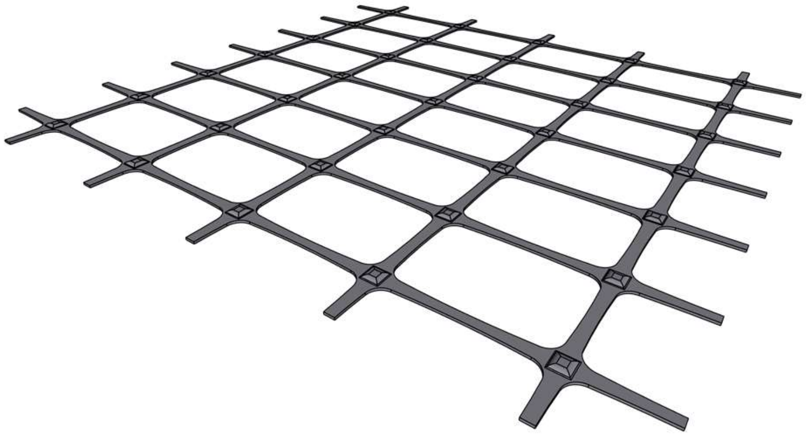


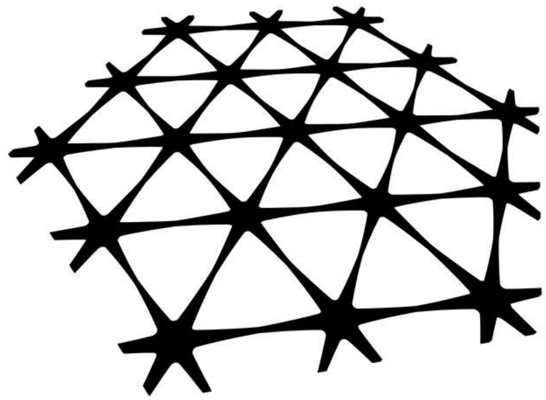


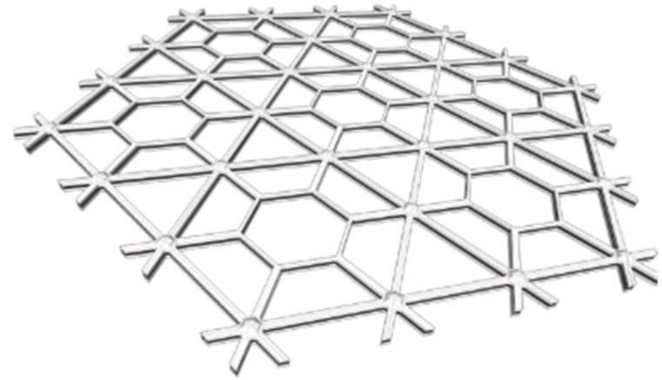
Geogrid Mechanics:
How do Geogrids Work?

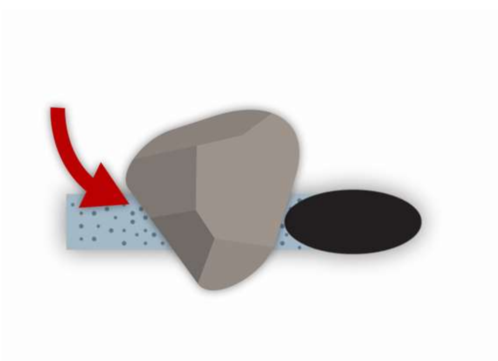
How do Geogrids work:

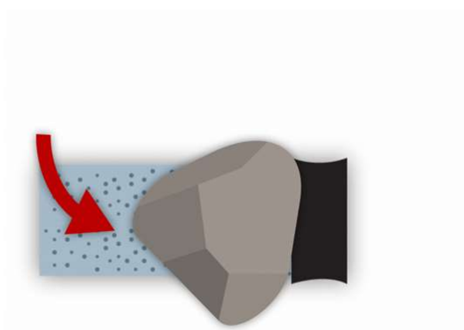
Rib Profile - Multiaxial Geogrid

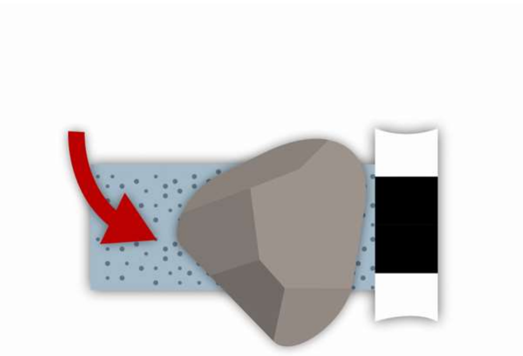










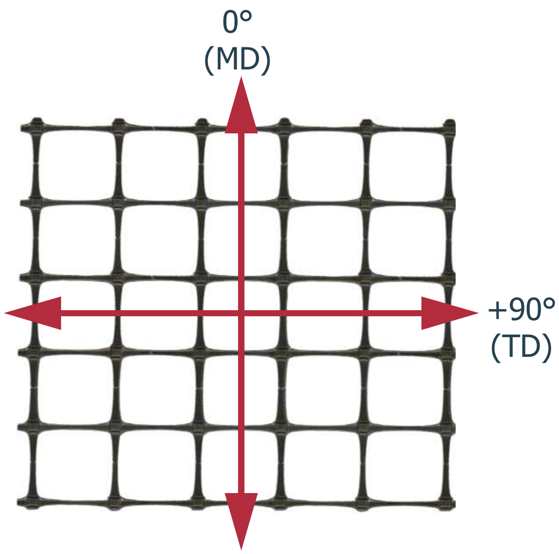


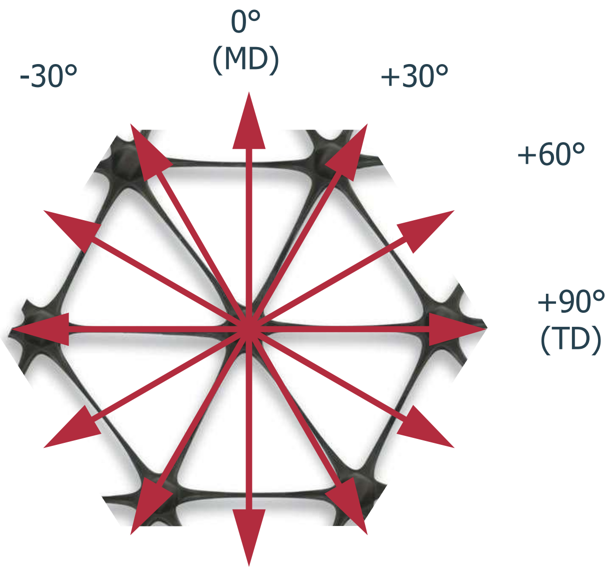
Scan to Access
Sign-In Sheet

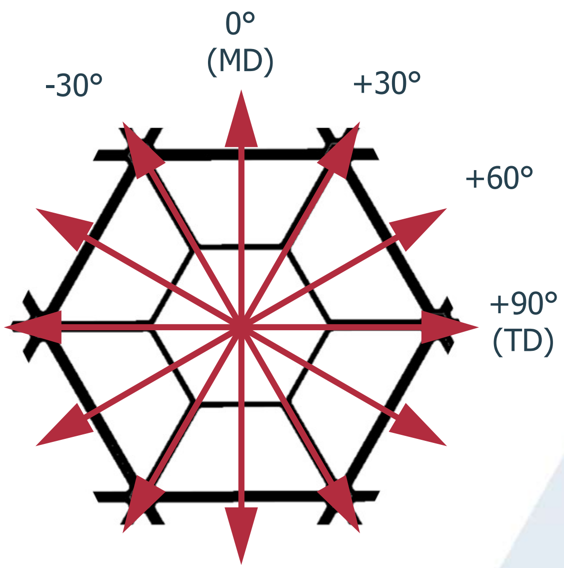
Tensar

How do Geogrids work:

Tensile Stiffness – Multiaxial Geogrid



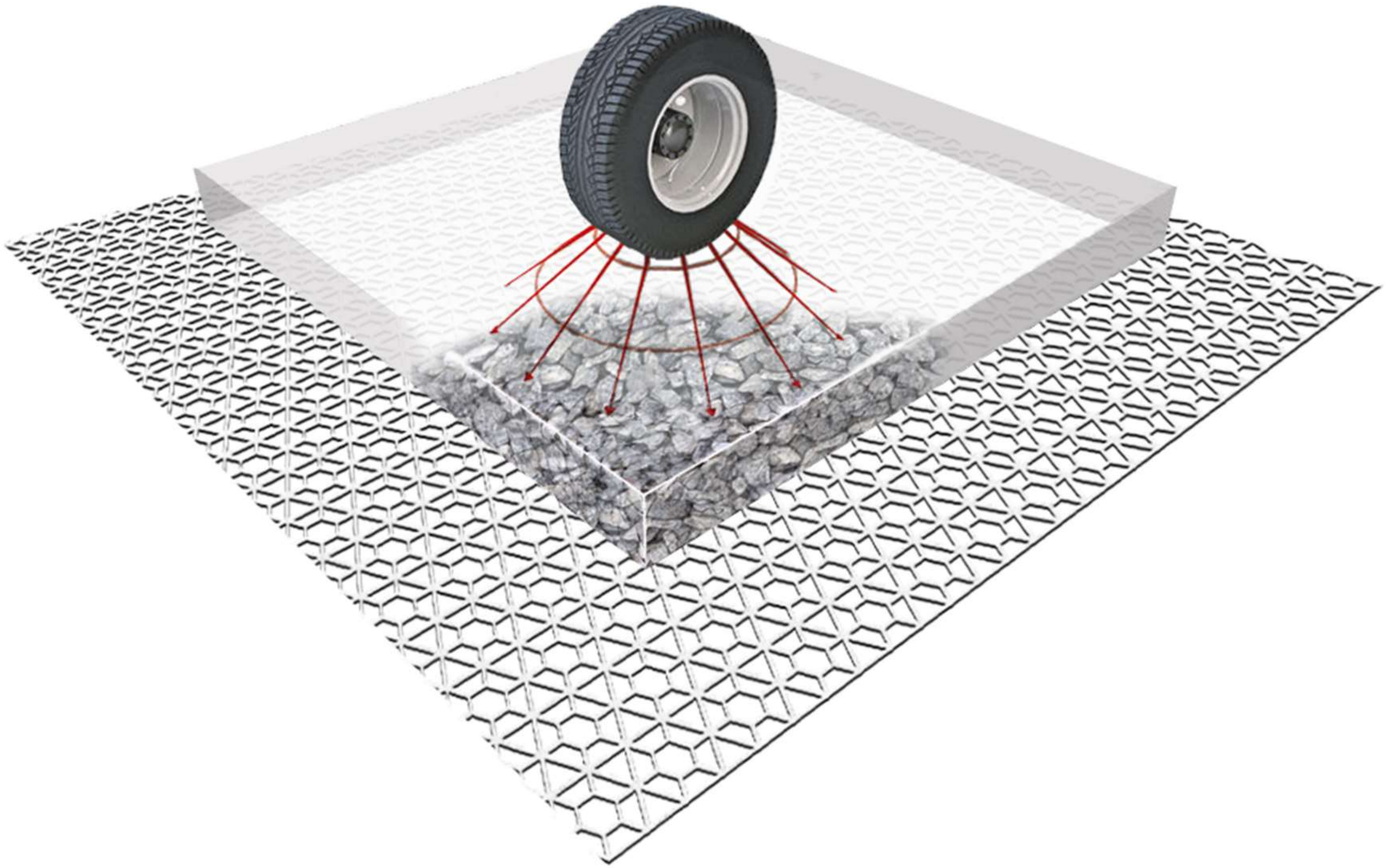




Scan to Access Sign-In Sheet

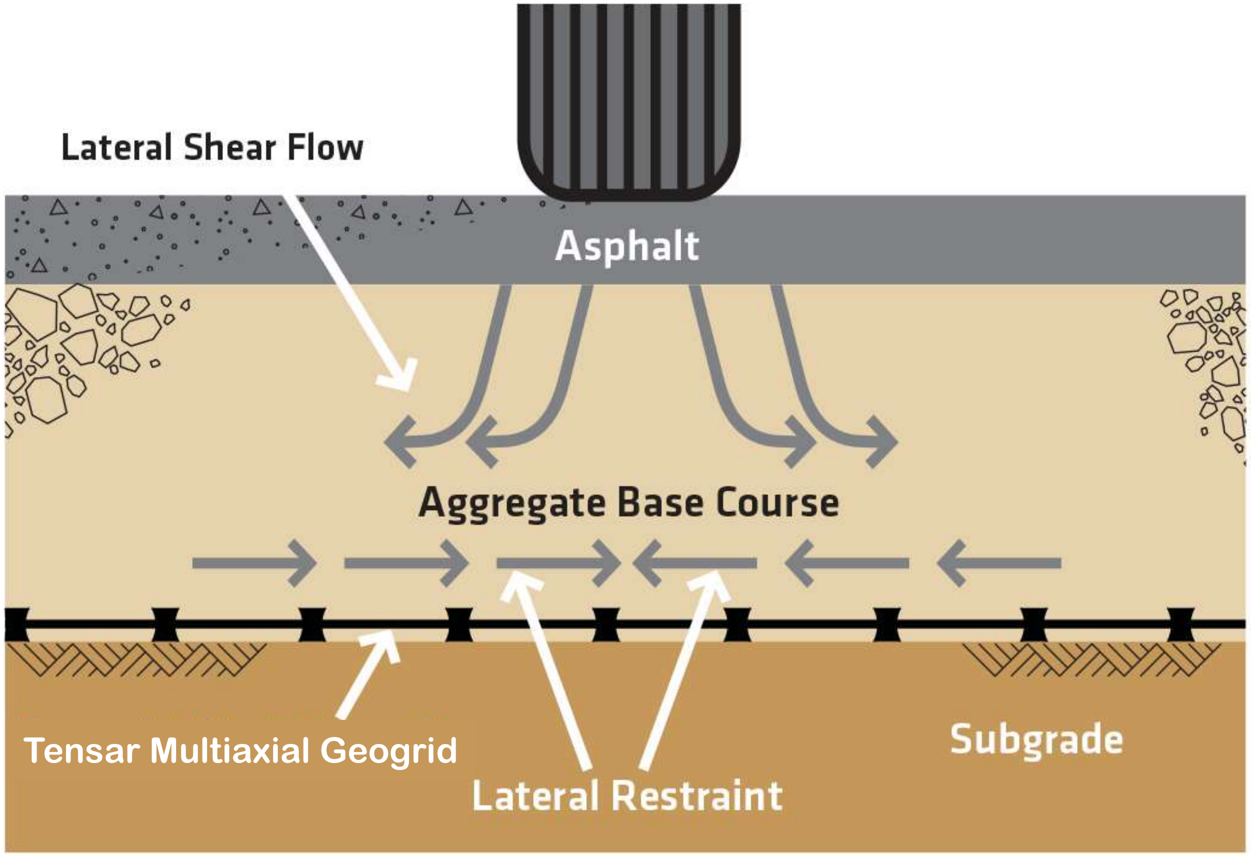
Tensar

Significance of Diagonal Ribs



Scan to Access
Sign-In Sheet

Mechanisms – Lateral Restraint

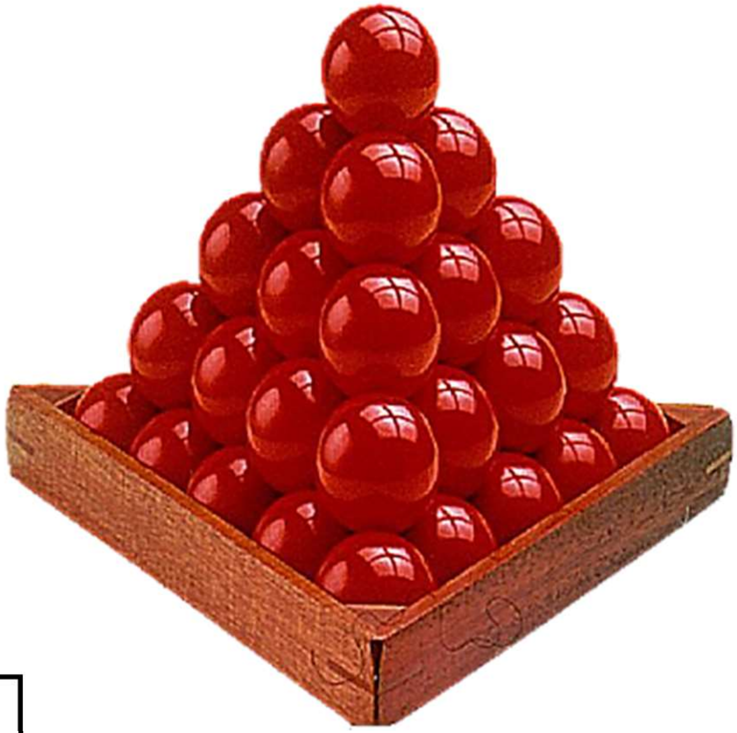


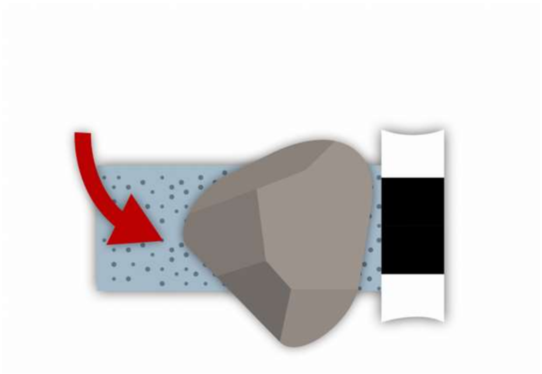
Source: USACOE ETL 1110-1-189

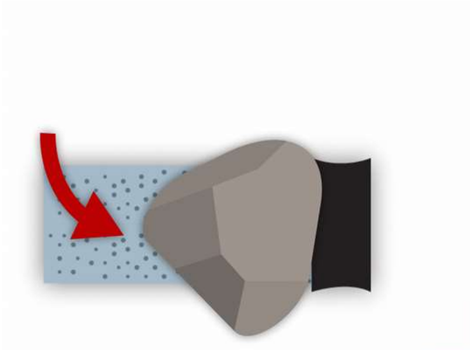
Scan to Access Sign-In Sheet

Tensar

Mechanisms – Lateral Restraint

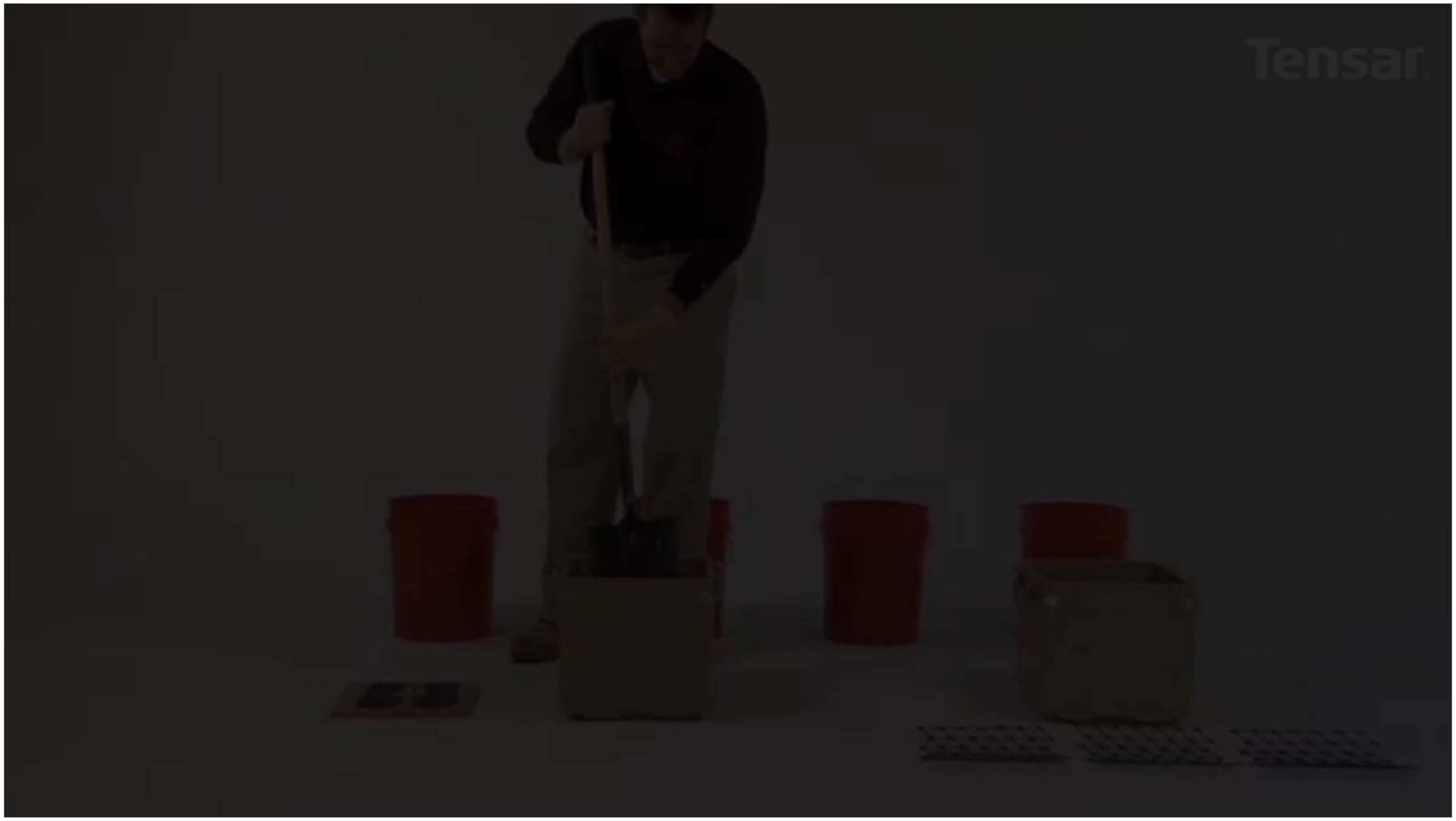






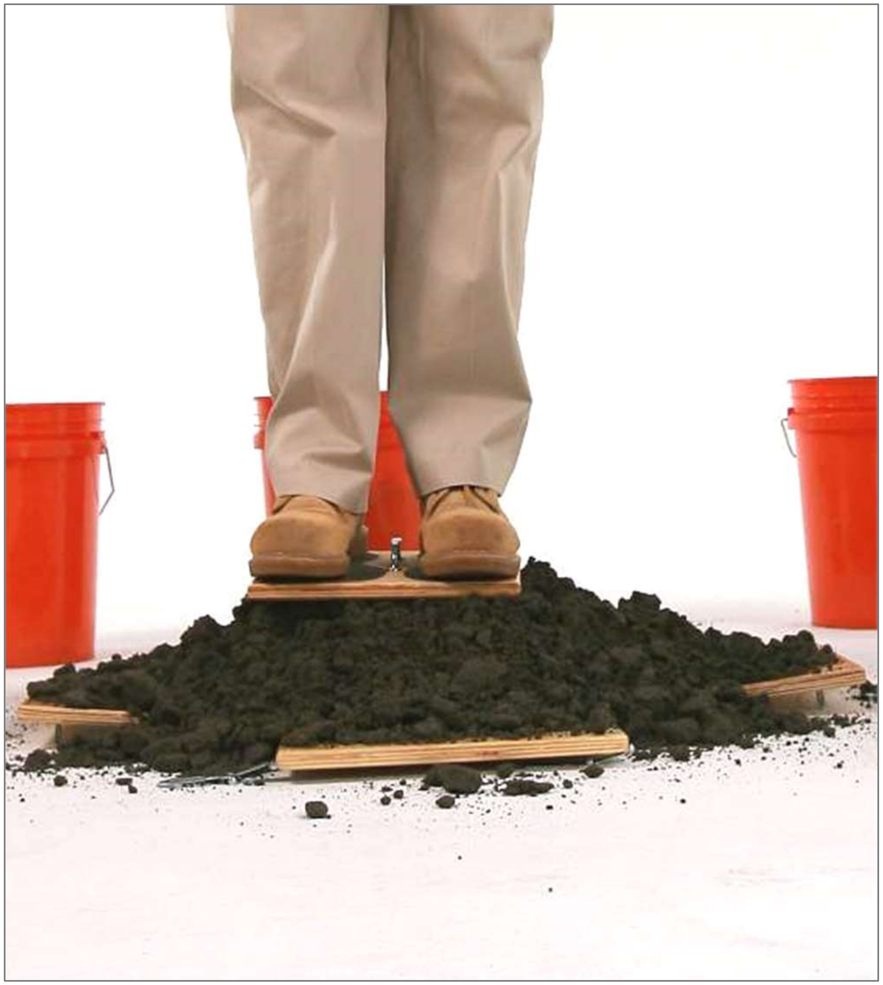
Scan to Access
Sign-In Sheet

Lateral Restraint in Action:
Box of Rocks Demonstration



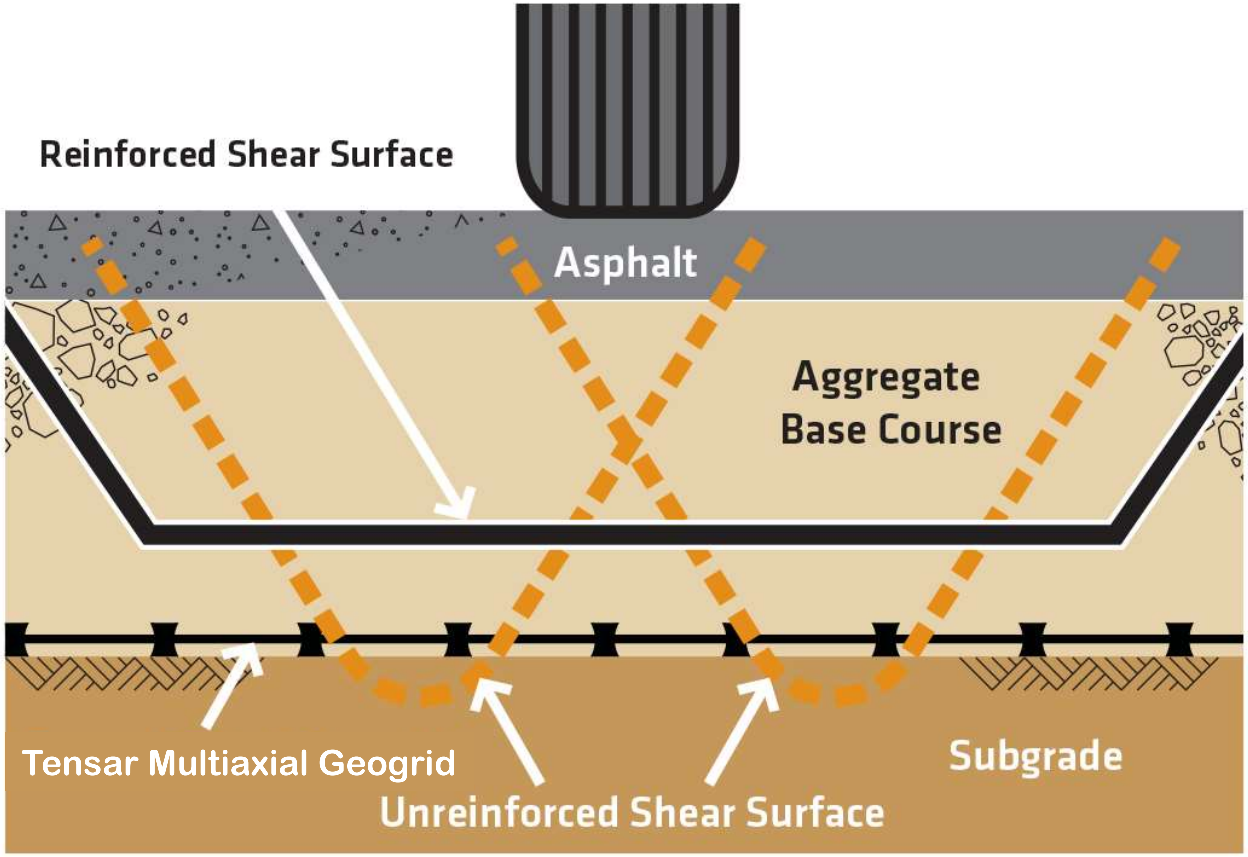
Scan to Access
Sign-In Sheet

Mechanisms – Lateral Restraint



Scan to Access
Sign-In Sheet

Mechanisms – Improved Bearing Capacity

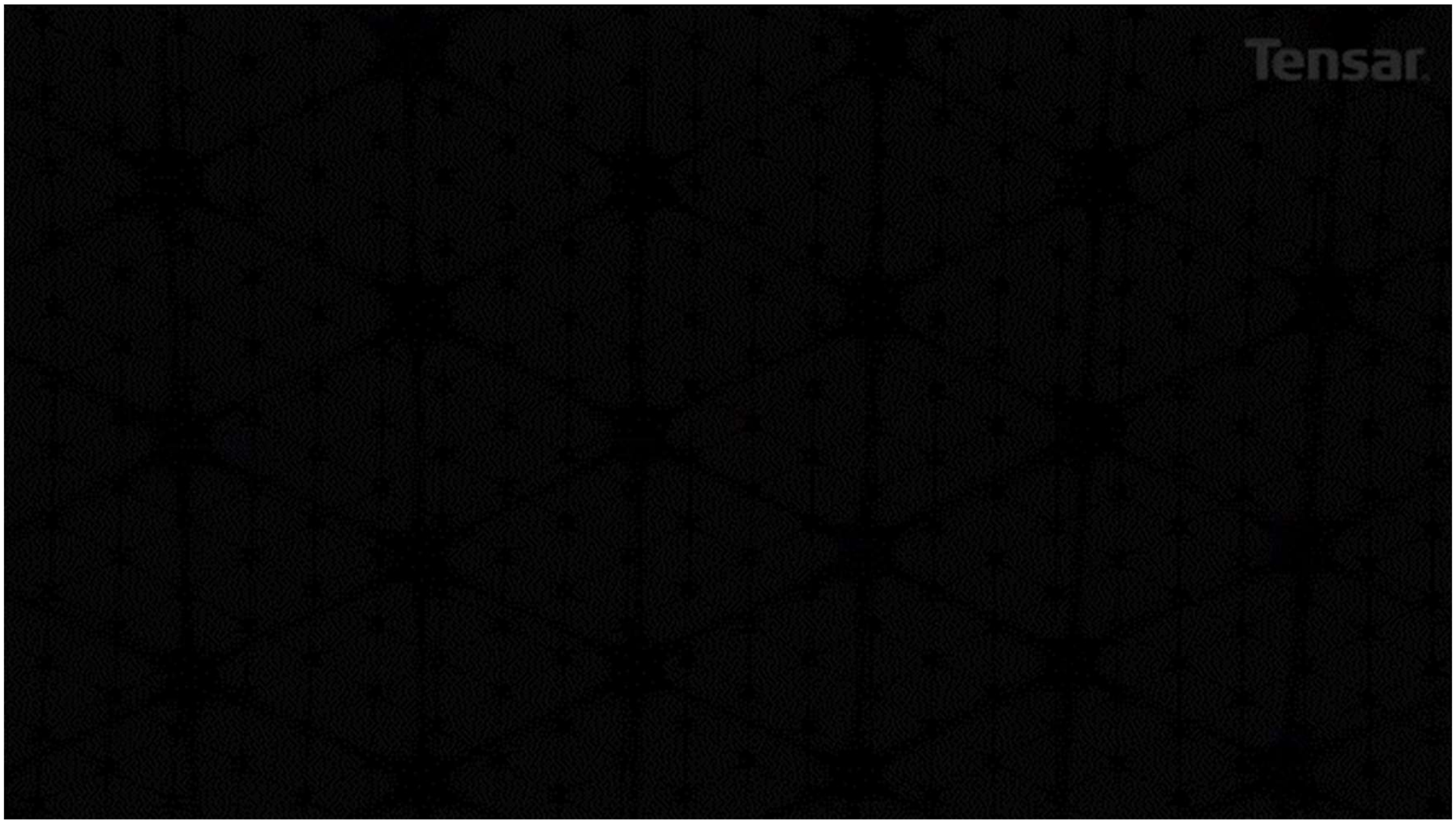


Source: USACOE ETL 1110-1-189

Scan to Access
Sign-In Sheet

Tensar

Improved Bearing Capacity in Action:
Sandbox Demonstration



Scan to Access
Sign-In Sheet

Improved Bearing Capacity in Action:
Big Sandbox Demonstration

Scan to Access
Sign-In Sheet

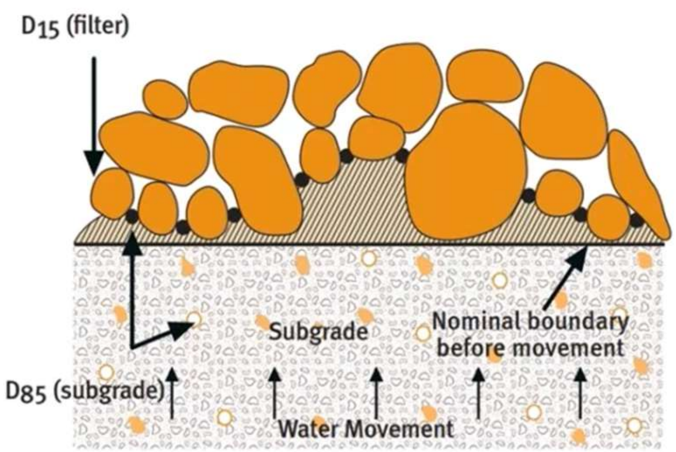
Mechanisms – Improved Bearing Capacity

Scan to Access
Sign-In Sheet

Tensar.

Mechanisms – Filtration & Separation

- *Filtration can be achieved using stabilization geogrids with properly graded fill*



Scan to Access Sign-In Sheet

Aggregate & Subgrade Rutting Profiles
Small scale trafficking comparison

Non-Stabilized Case
3,000 Passes

BX Geogrid
10,000 Passes

TriAx Geogrid
10,000 Passes

Scan to Access Sign-In Sheet

Tensar

Aggregate & Subgrade Rutting Profiles

Small-Scale Trafficking Comparison

Non-Stabilized
10,000 Passes

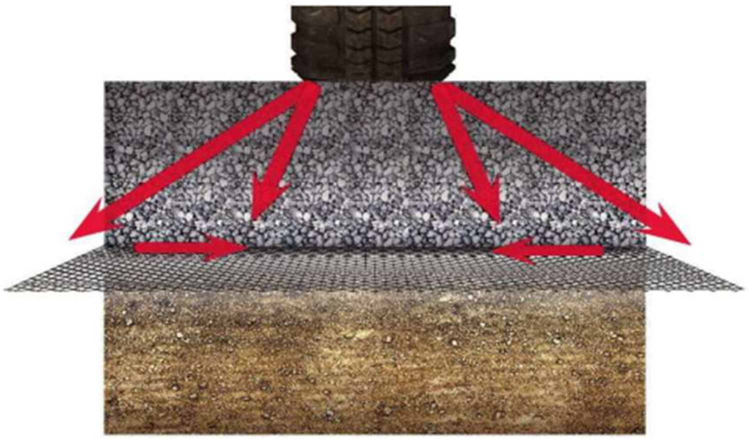
TriAx Geogrid
10,000 Passes

InterAx Geogrid
10,000 Passes

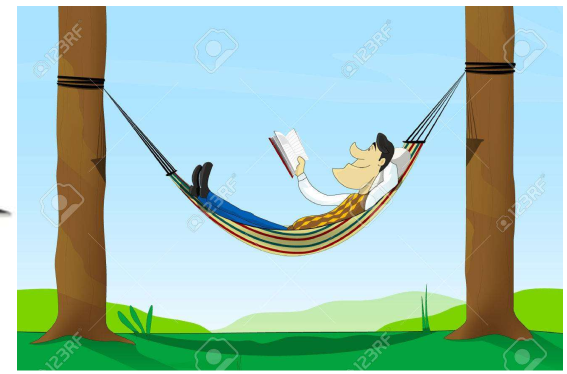
Scan to Acces
Sign-In Shee

Strength and Roadway Surface Deformation

Stabilization



Reinforcement



- Lateral Restraint
- Confinement
- Interlock
- Radial Stiffness

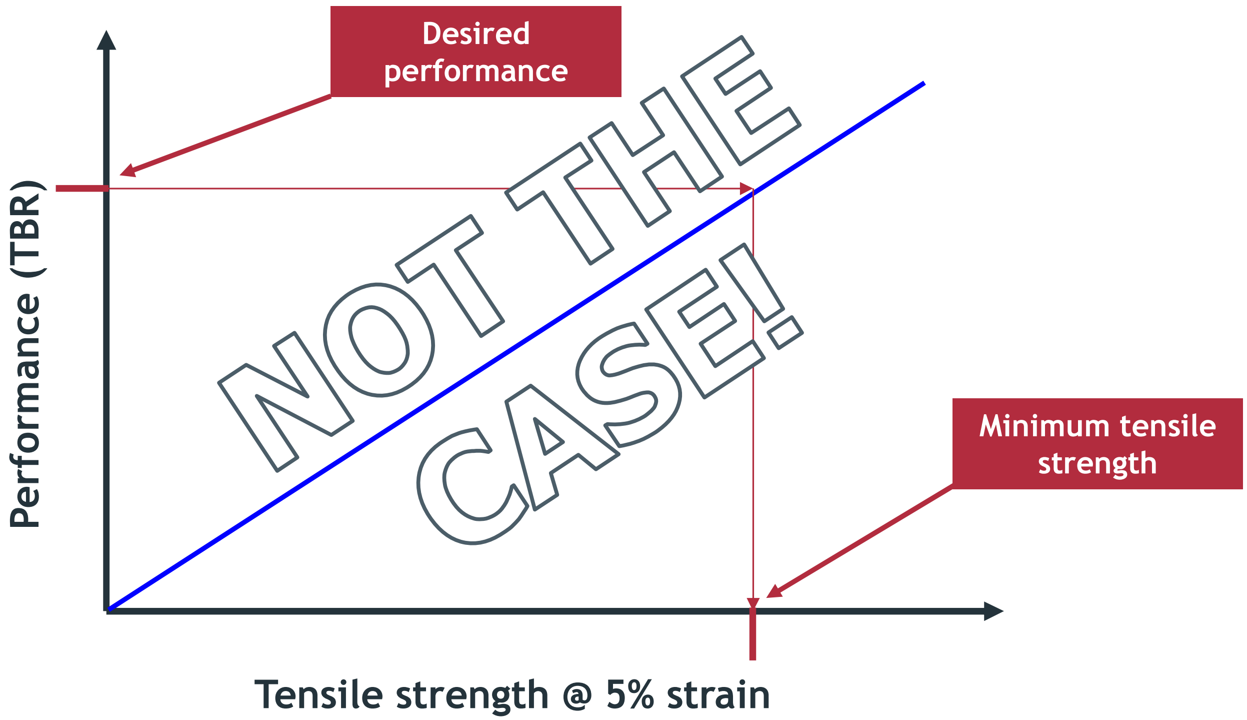
Limits Deformation
<u>Not Reliant on Tensile Strength</u>

- Tensioned Membrane
- Anchorage
- Friction
- Strength (Modulus) Relevant

Scan t
Sign-

Strength and Roadway Surface Deformation

Calibration – Giroud Han (2004)



Scan to Access
Sign-In Sheet

Tensar

Strength and Roadway Surface Deformation

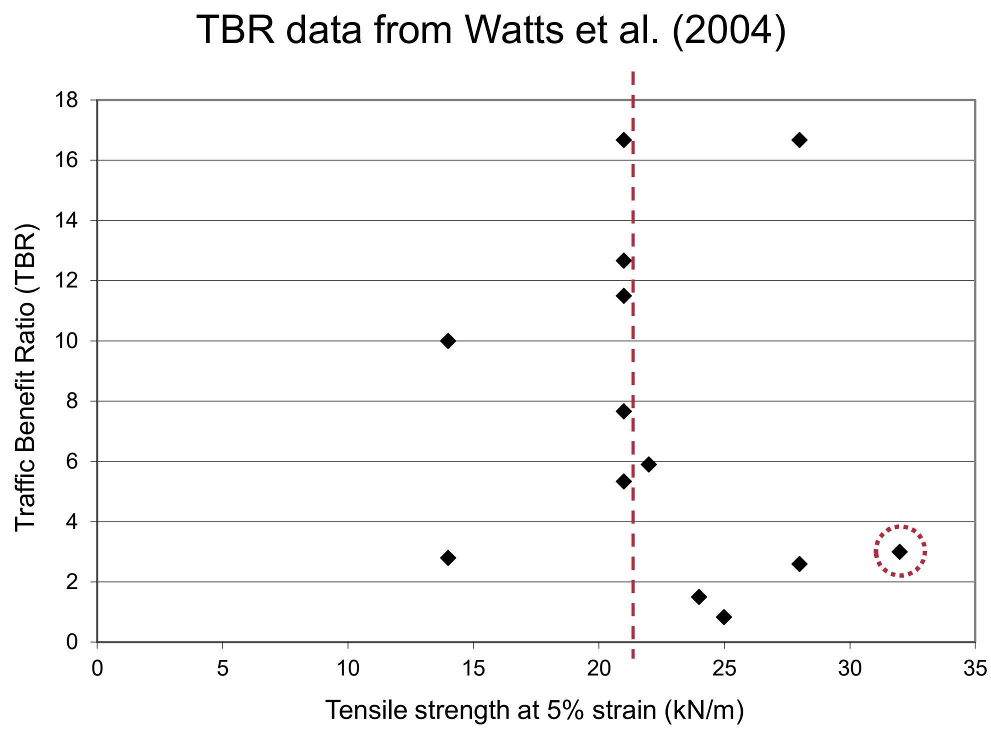
Calibration – Giroud Han (2004)

Watts et al. (2004)

Scan to Access Sign-In Sheet

Tensar

Strength and Roadway Surface Deformation



Scan to Access Sign-In Sheet

- Twelve different types of geogrid and one woven geotextile tested
- Geogrids types included punched and stretched, extruded, woven, junction bonded, and composite geogrids

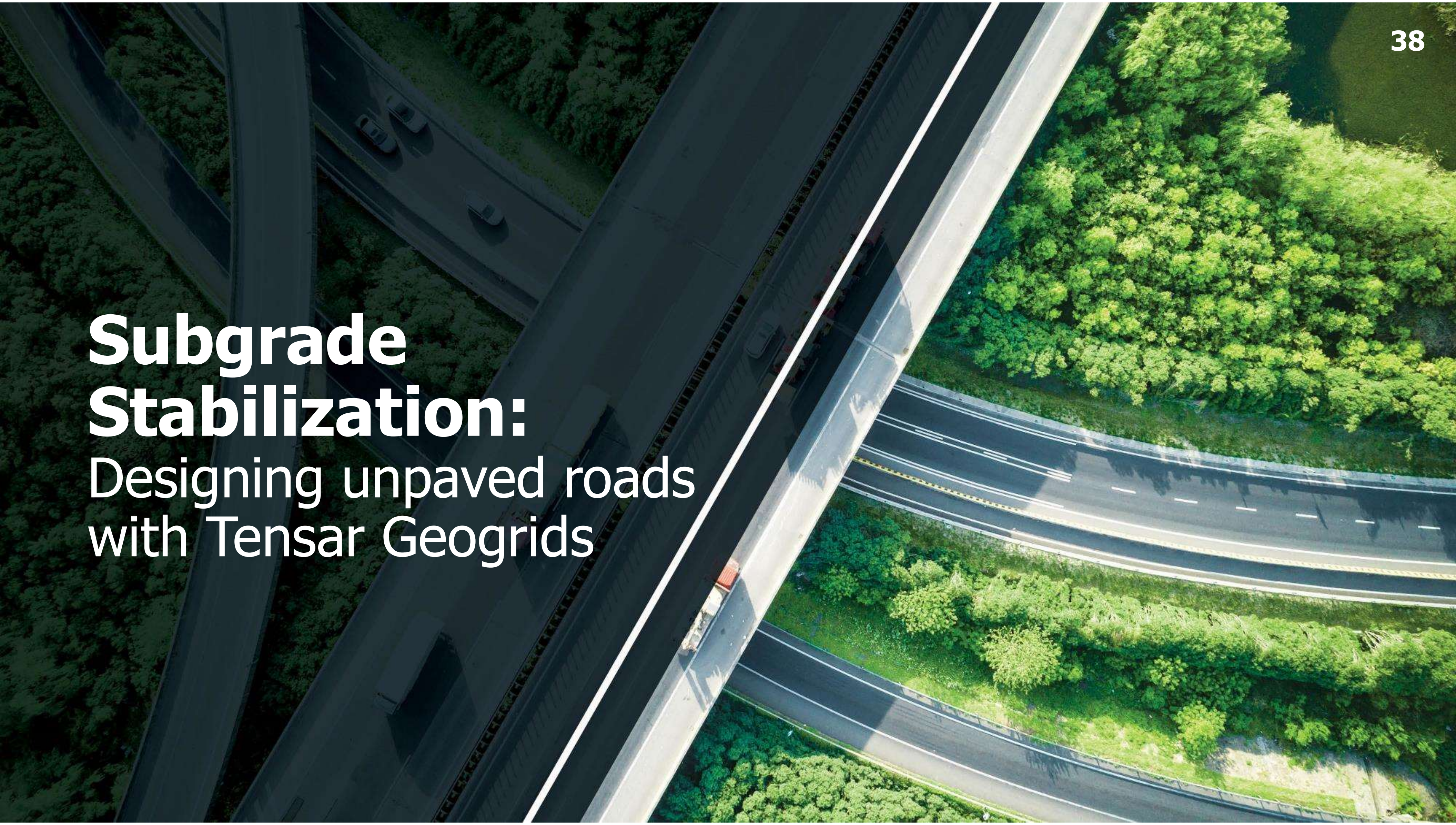
Tensar

Why Trust Tensar Geogrids?

- Full scale testing and calibration – period

Scan to Access Sign-In Sheet

Material index properties can describe a product but do not predict performance and are not used as design inputs for any widely accepted design method for subgrade stabilization or pavement optimization applications

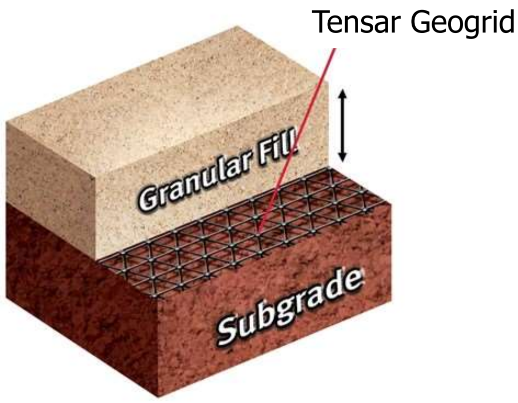


Subgrade Stabilization:

Designing unpaved roads with Tensar Geogrids

Geogrid Applications: Subgrade Stabilization

- Subgrade Stabilization (Unpaved)
  - Bridge over soft soils
  - Establish working surface
  - Reduce fill thickness
  - Reduce or eliminate undercut
  - Replace mechanical mixing
  - Replace chemical stabilization
  - Provide uniform support condition
  - Reduce maintenance



Unpaved Surfaces/ Construction Platforms

Scan to Access Sign-In Sheet

Tensar

Unpaved Road/Surface Design Process

How are Tensar Geogrids used in practice?

The University of Kansas
Lawrence, KS 66045

Jie Han, Ph.D., PE
Professor
Department of Civil, Environmental, Architectural Engineering
Learned Hall, 1530 West 15th Street

Tel: (785) 864-3714
Fax: (785) 864-5631

E-mail: jiehan@ku.edu

Dr. Mark H. Wayne, PE
Application Technology Manager
Tensar International Corporation
2500 Northwinds Pkwy, Suite 500
Alpharetta, GA 30009

August 15, 2011

Dear Dr. Wayne,

Thank you for providing me the opportunity to review the design method used by Tensar for designing with TriAx® geogrid products in unpaved road applications. Based on my review, I can confirm that the design method follows the Giroud-Han Methodology as published in the FHWA Reference Manual FHWA NHI-07-092 Geosynthetic Design and Construction Guidelines. Additionally, the approach you took to calibrate the design method for the TriAx® geogrids is consistent with what Dr. J.P. Giroud and I performed for the Tensar biaxial geogrids.

Sincerely yours,

Jie Han, Ph.D., PE, Professor

Scan to
Sign-I

Information Needed for Subgrade Stabilization

Subgrade strength

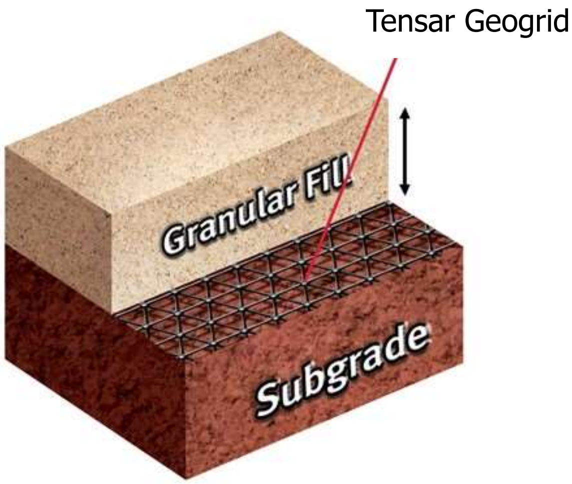
- CBR/LBR/Resilient Modulus (Mr)
- Geotechnical Report
- Visual Observations
- Field Quantification

Loading

- Axle Loads
- Tire Pressure
- Number of Vehicle Passes

Type of fill

- Gradation
- Soil Classification



Scan to Access Sign-In Sheet

Unpaved Haul/Access Road Example

Given:

- At-grade road construction
- Roadway geometry of 8 miles long by 13 feet wide (61,000 SY)
- Axle load of 22 kips
- Tire pressure of 110 psi
- 100,000 axle passes
- Maximum rut depth of 1.5 inches
- Aggregate fill CBR of 60 %
- Design subgrade CBR of 2 %
- Installed cost of aggregate of $25 per ton
- Excavation/Undercut of $5 per cubic yard
- Delivered cost of geotextile fabric of $0.75 per square yard
- Delivered cost of biaxial geogrid of $1.50 per square yard
- Delivered cost of TriAx Geogrid of $3.75 per square yard
- Delivered cost of InterAx Geogrid of $5.50 per square yard
- Geosynthetic installation cost of $0.75 per square yard

Determine Solution Costs For The Following:

- Unstabilized section
- Geotextile fabric section
- Biaxial geogrid section
- TriAx Geogrid section
- InterAx Geogrid section

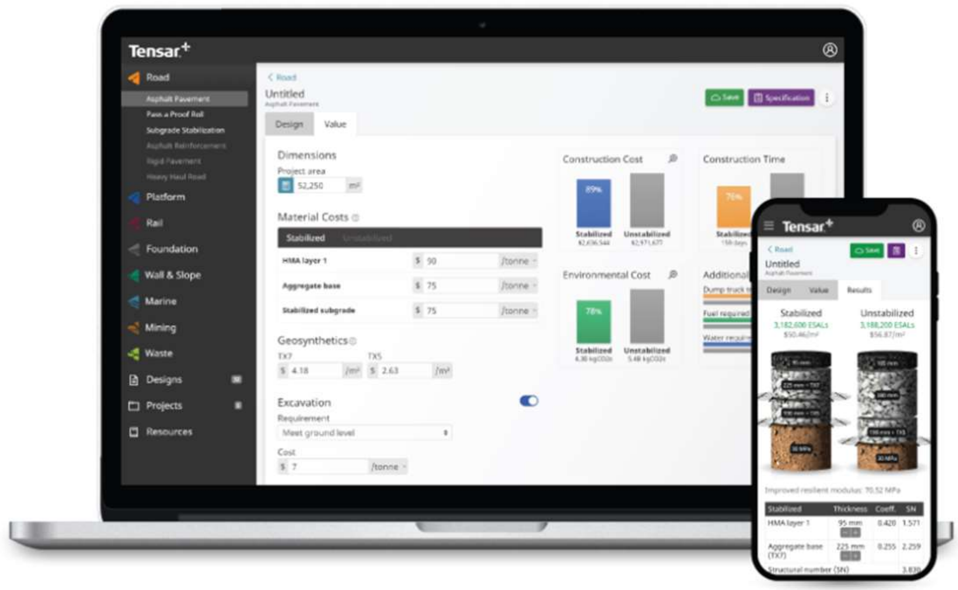
Scan to Access Sign-In Sheet

Tensar+™

The newly enhanced, cloud-based design software features a simplified user experience with all the features engineers have come to expect and depend upon. And now, you can create, save, and access designs across your multiple devices.

Tensar+ / Tensar+

Design with confidence, from anywhere.



- Design & evaluate pavement and gravel sections
- Easily compare alternative materials
- Determine initial and lifecycle cost savings, time savings, and sustainability metrics
- High-level summary of the design alternatives for project stakeholders
- Sharing features that aid collaboration

Scan to Access Sign-In Sheet

Sign up & start designing today at:

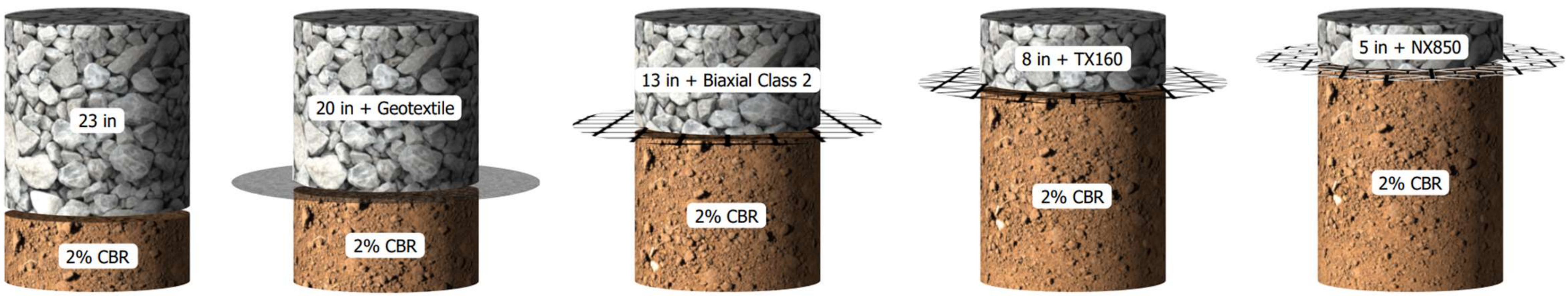
www.tensarplus.com

- Powerful
- Reliable
- Valuable
- Versatile

Tensar.

Unpaved Haul/Access Road Example

Unstabilized	Geotextile Fabric	Biaxial Geogrid	TriAx Geogrid	InterAx Geogrid
Total Cost: $32.30/SY	Total Cost: $29.13/SY	Total Cost: $20.50/SY	Total Cost: $15.73/SY	Total Cost: $13.27/SY
Total Project Cost: $1,970,559	Total Project Cost: $1,777,593	Total Project Cost: $1,251,074	Total Project Cost: $959,972	Total Project Cost: $809,716



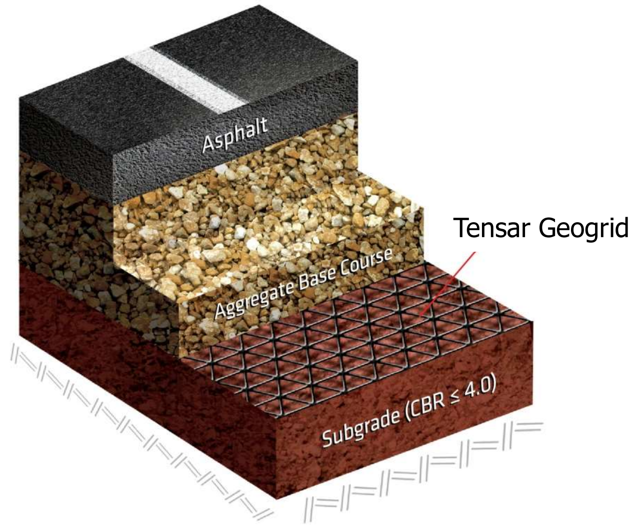
Scan to Access Sign-In Sheet

These costs do not account for time savings. In addition, value associated with dump truck trips, fuel consumption, cost of traffic delay, etc. has not been reflected in the evaluation.

Pavement Optimization:
Designing paved roads with Tensar Geogrids

Geogrid Applications: Pavement Optimization

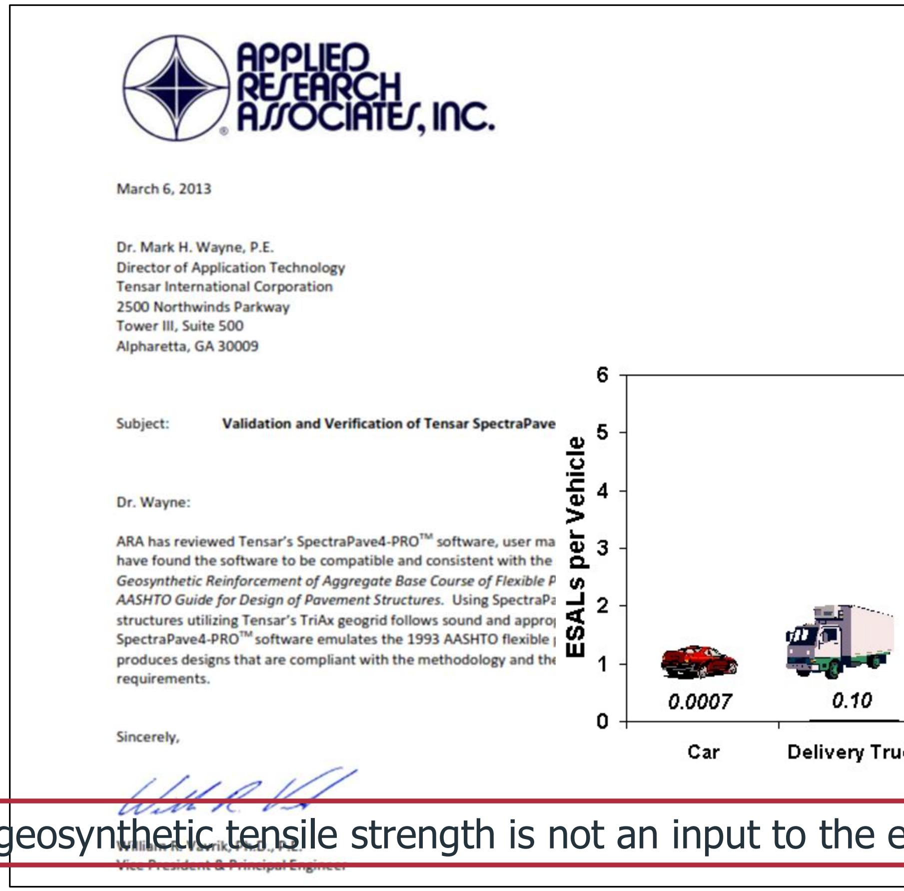
- Pavement Optimization (paved)
  - Stiffen aggregate base material
  - Reduce aggregate/asphalt thickness
  - Replace mechanical mixing
  - Provide increased reliability
  - Reduce maintenance
  - Extend roadway life



Paved Roads (Flexible)

Paved Road Design Process

How are Tensar Geogrids used in practice?



APPLIED RESEARCH ASSOCIATES, INC.

March 6, 2013

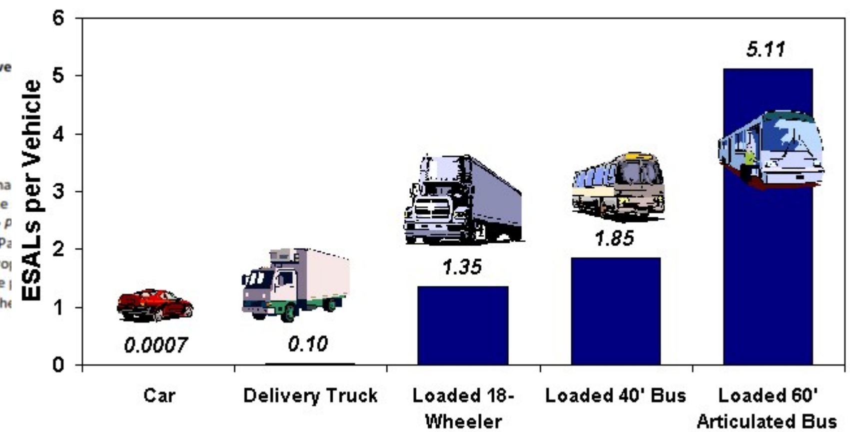
Dr. Mark H. Wayne, P.E.
Director of Application Technology
Tensar International Corporation
2500 Northwinds Parkway
Tower III, Suite 500
Alpharetta, GA 30009

Subject: **Validation and Verification of Tensar SpectraPave**

Dr. Wayne:

ARA has reviewed Tensar's SpectraPave4-PRO™ software, user ma
have found the software to be compatible and consistent with the
Geosynthetic Reinforcement of Aggregate Base Course of Flexible P
AASHTO Guide for Design of Pavement Structures. Using SpectraPa
structures utilizing Tensar's TriAx geogrid follows sound and appro
SpectraPave4-PRO™ software emulates the 1993 AASHTO flexible
produces designs that are compliant with the methodology and th
requirements.

Sincerely,

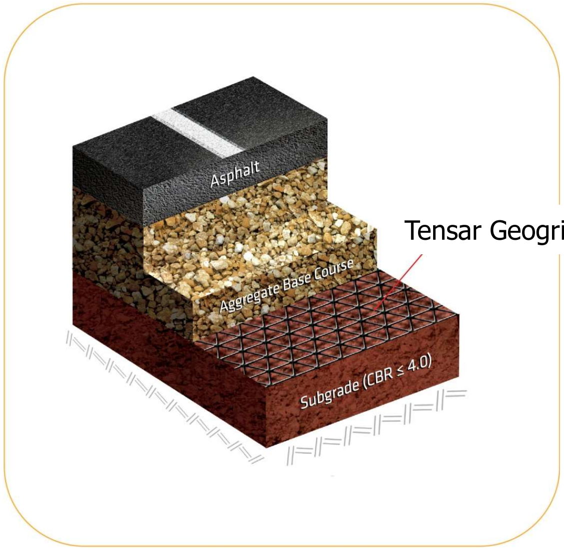


Note that geosynthetic tensile strength is not an input to the equation

Scan to Access Sign-In Sheet

Information Needed for Pavement Optimization

- Section Details
- AASHTO Design Inputs
- Traffic – ESALs
- Soils Report – Design Subgrade Strength

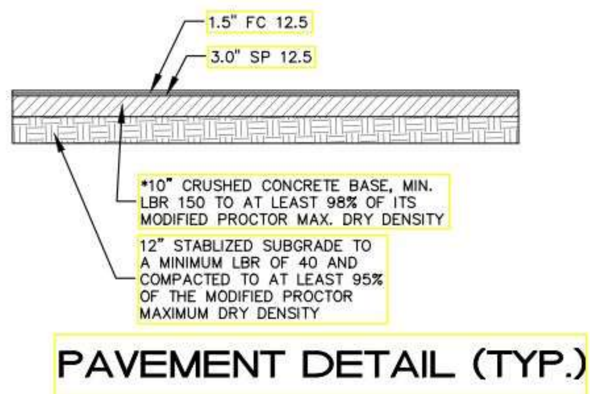


Scan to Access Sign-In Sheet

Tensar

Paved Road Example

- Commercial Development in Lakeland, FL



*PAVEMENT AREAS WHERE SEASONAL HIGH WATER IS WITHIN 18" OF BASE MATERIAL SHALL HAVE AN ALTERNATE MOISTURE TOLERANT BASE SUCH AS CRUSHED CONCRETE, SOIL CEMENT, OR CRUSHED SHELL.

STRUCTURAL NUMBER CALCULATIONS:

FRICTION COURSE	- SP 12.5	- 0.44/INCH x 1.5" = 0.66
STRUCTURAL COURSE	- SP 12.5	- 0.44/INCH x 3.0" = 1.32
BASE	- CRUSHED CONCRETE	- 0.18/INCH x 10.0"= 1.80
SUBGRADE	- TYPE B STAB. LBR OF 40	- 0.08/INCH x 12.0"= 0.96

PROPOSED STRUCTURAL NUMBER = 4.74
(MINIMUM STRUCTURAL NUMBER = 2.50)

ROAD DESIGN NOTE:

DESIGN SPEED FOR ALL ROADS: 30 MILES/HOUR.

- Develop geogrid solutions for pavement section and compare to conventional section
- Geogrid solutions must provide equivalent or greater traffic capacity when compared to the conventional section
- Total pavement section area of 80,000 square yards

Scan to Access
Sign-In Sheet

Tensar

Paved Road Example

- Given
  - Reliability of 90 %
  - Standard deviation of 0.45
  - Subgrade resilient modulus of 5,000 psi
  - Initial serviceability of 4.2
  - Terminal serviceability of 2.5
  - Installed cost of asphalt of $100 per ton
  - Installed cost of crushed concrete base of $25 per ton
  - Installed cost of Type B Stabilization (LBR 40) of $7 per ton
  - Installed cost of Tensar TriAx Geogrid of $5 per square yard

- Evaluate different geogrid options that provide equivalent or greater traffic capacity when compared to the unstabilized pavement section

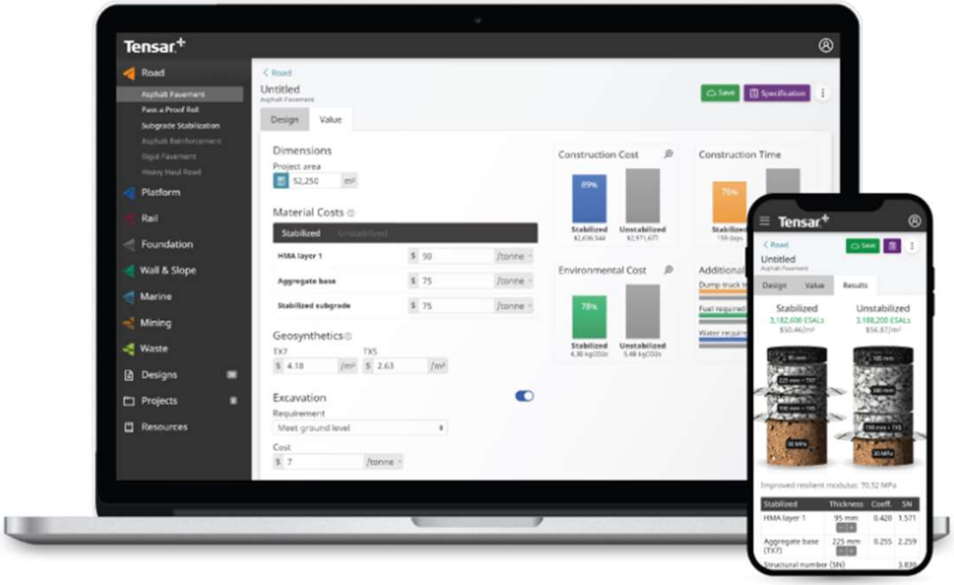
Scan to Access
Sign-In Sheet

Tensar+™

The newly enhanced, cloud-based design software features a simplified user experience with all the features engineers have come to expect and depend upon. And now, you can create, save, and access designs across your multiple devices.

Tensar+ / Tensar+

Design with confidence, from anywhere.



- Design & evaluate pavement and gravel sections
- Easily compare alternative materials
- Determine initial and lifecycle cost savings, time savings, and sustainability metrics
- High-level summary of the design alternatives for project stakeholders
- Sharing features that aid collaboration

Scan to Access Sign-In Sheet

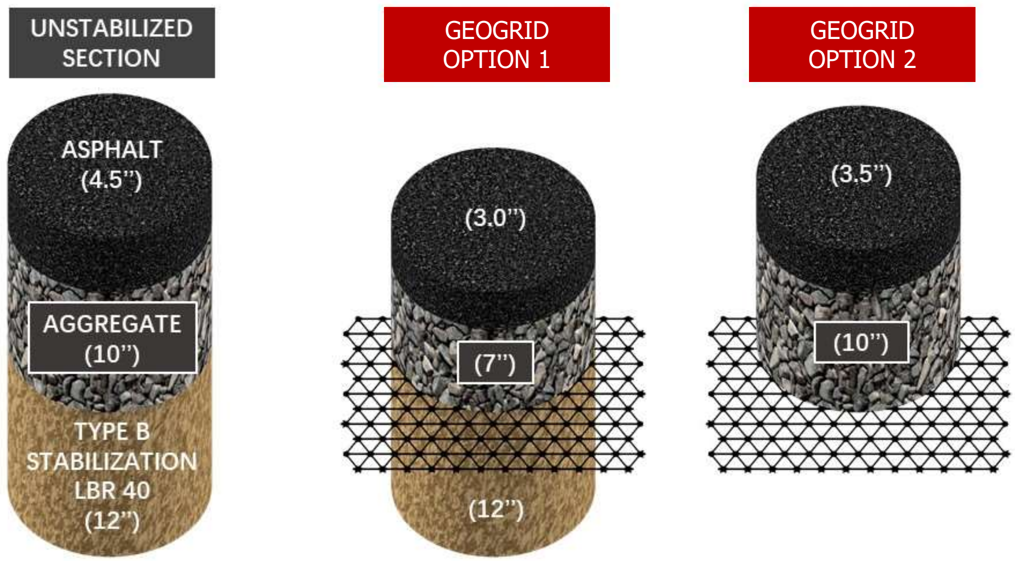
Sign up & start designing today at:

www.tensarplus.com

- Powerful
- Reliable
- Valuable
- Versatile

Tensar®

Paved Road Example



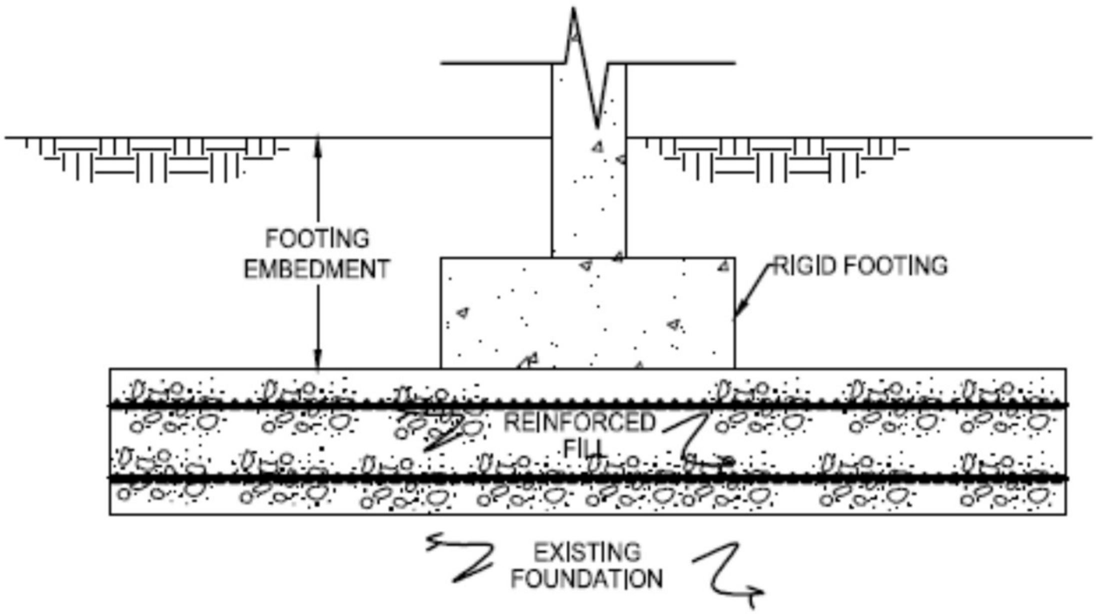
UNSTABILIZED SECTION	GEOGRID OPTION 1	GEOGRID OPTION 2
TOTAL COST: $41.88/SQ.YD	TOTAL COST: $34.76/SQ.YD	TOTAL COST: $37.08/SQ.SY
TOTAL PROJECT COST: $3,350,400	TOTAL PROJECT COST: $2,780,800	TOTAL PROJECT COST: $2,966,400

Scan to Access Sign-In Sheet

These geogrid options do not account for time savings or reduction of undercut and removal if grade is fixed at the site. In addition, value associated with dump truck trips, fuel consumption, cost of traffic delay, etc. has not been reflected in the evaluation

Additional Geogrid Applications

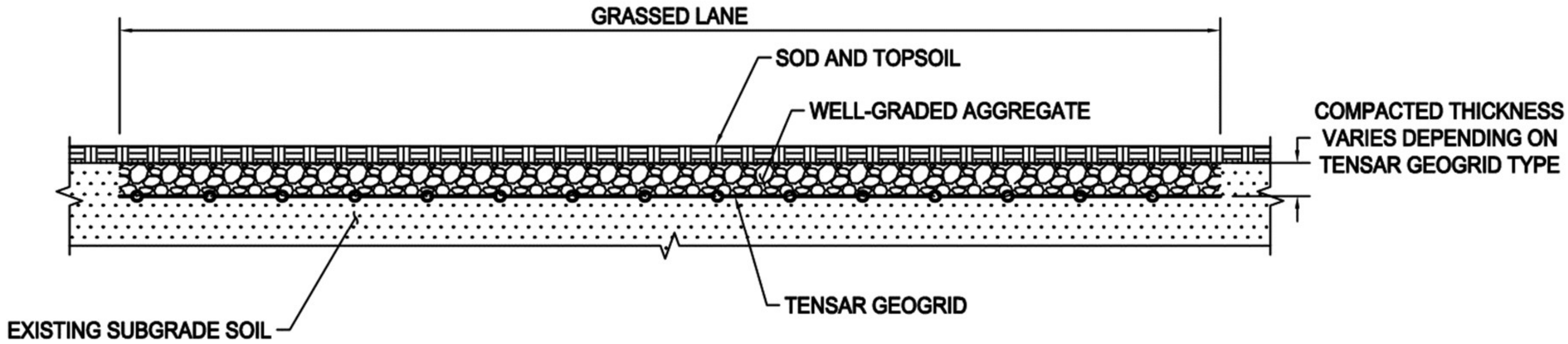
Foundation Improvement



TYPICAL FOOTING CROSS-SECTION

Scan to Access
Sign-In Sheet

Grassed Emergency/Fire Lane



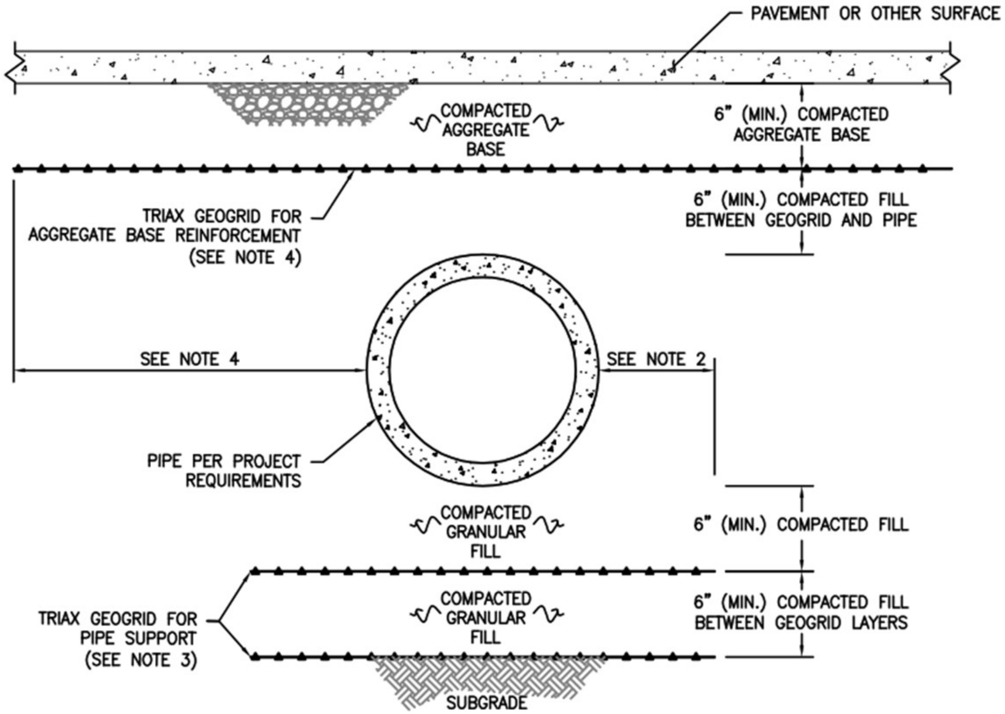
GRASSED LANE SECTION DETAIL

NOT TO SCALE

Scan to Access Sign-In Sheet

Tensar

Structure and Utility Support



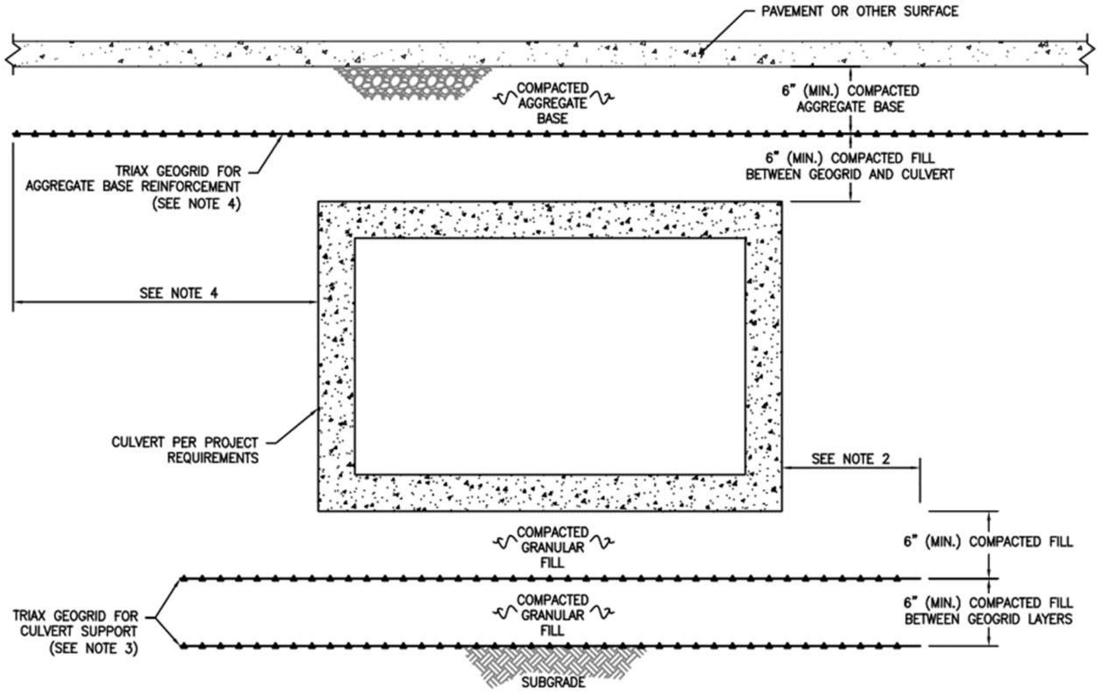
TYPICAL SECTION – GEOGRID AT PIPE BENEATH ROADWAY

NOT TO SCALE

Scan to Access Sign-In Sheet

Tensar

Structure and Utility Support



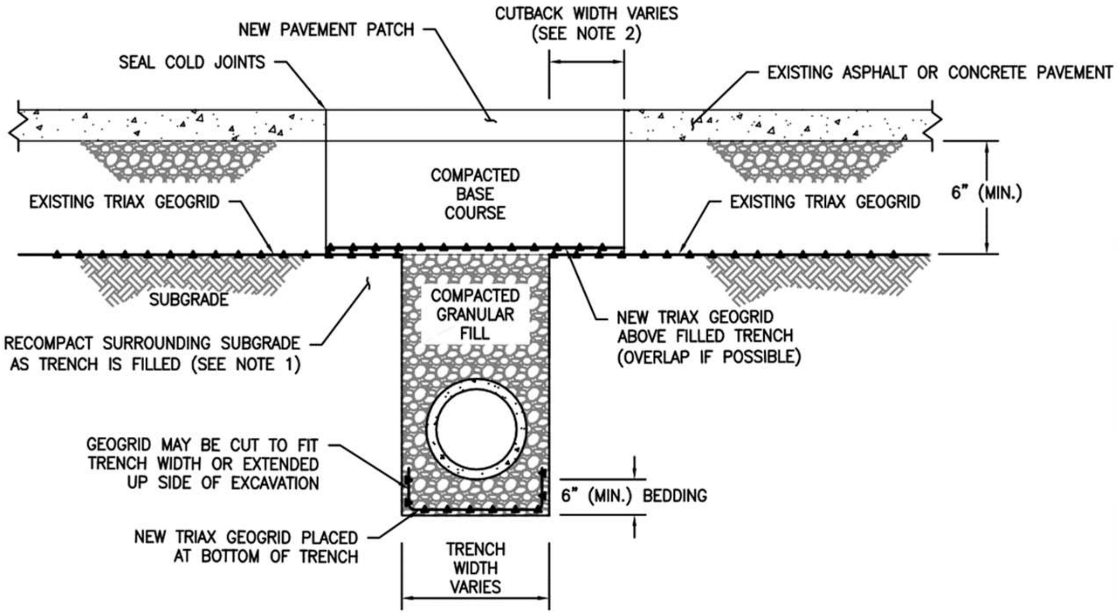
TYPICAL SECTION – GEOGRID AT BOX CULVERT BENEATH ROADWAY

NOT TO SCALE

Scan to Access Sign-In Sheet

Trenching Through Geogrids

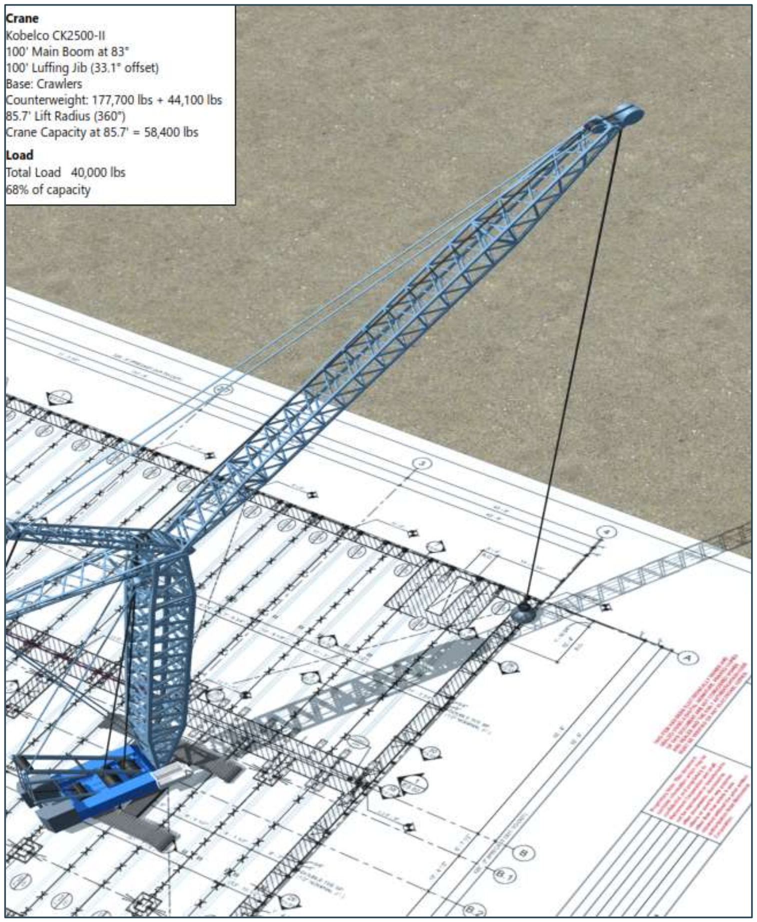
- Tensar geogrids are routinely excavated and punched through in order to place guardrail posts, bridge piers, underground utilities, etc.
- Since the geogrid works through interlock, and not as a tensile element, excavation through the geogrid does not compromise its benefit.

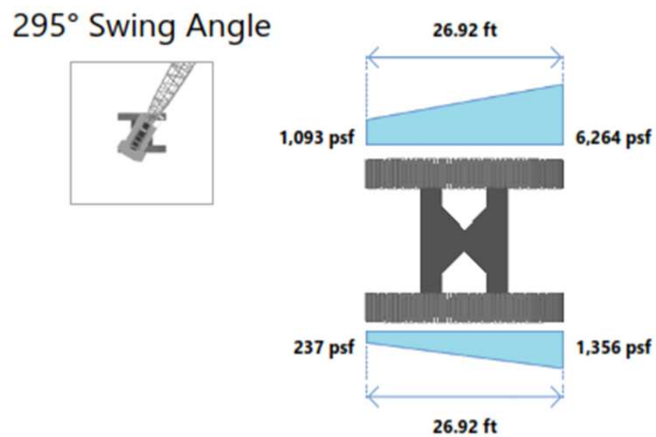


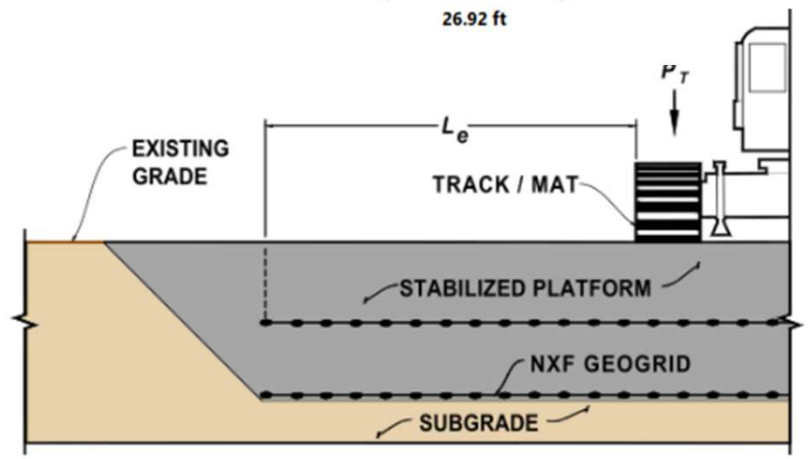
Scan to Access Sign-In Sheet

Crane Pads/Mats

Facilitate construction of working platforms for crane operations







Scan to Access Sign-In Sheet

Heavy-Duty Pavements

Ports, Manufacturing and Distribution Facilities, etc.

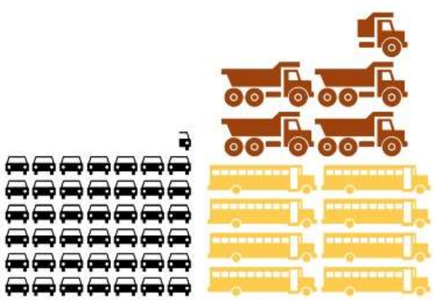
PCASE software by the US Army Corps of Engineers

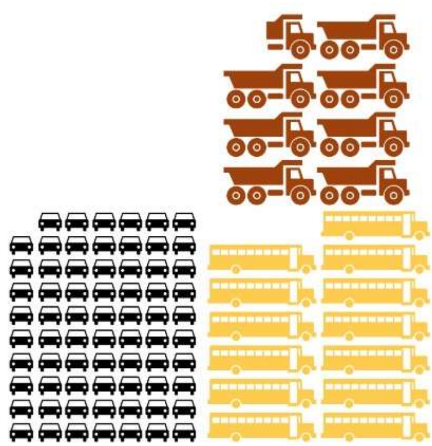
Unstabilized Pavement Section

	Thickness	Coeff.	SN
HMA layer 1	4 in	0.440	1.760
Aggregate base	12 in	0.180	2.160
Subbase	12 in	0.080	0.960
Structural number (SN)			4.880
Calculated traffic (ESALs)			15,423,100

TriAx Stabilized Pavement Section

	Thickness	Coeff.	SN
HMA layer 1	3 in	0.440	1.320
Mechanically stabilized layer	8 in	0.337	2.696
Subbase	12 in	0.080	0.960
Structural number (SN)			4.976
Calculated traffic (ESALs)			17,659,900





Scan to Access Sign-In Sheet

Thank you!

ASCE
FLORIDA SECTION
Palm Beach Branch

Tensar