Tensar

Geosynthetics for Roadway Design Applications

November 30, 2022

FACERS
Florida Association of County Engineers & Road Superintendents

Introductions

Paul Schmitz

Tensar Corp.

Market Manager – Public Roads

pschmitz@tensarcorp.com

Receive Your Electronic PDH

Select Course #101

Agenda

- Geosynthetics Overview
- Geogrid Mechanisms
- Subgrade Stabilization
- Pavement Optimization
- Local Case Studies
- Installation
- Testing

Types of Geosynthetics

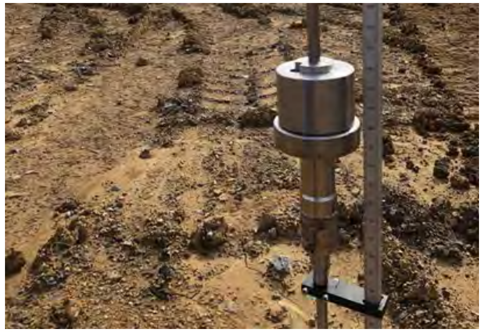
Koerner, R. M. (2012). *Designing With Geosynthetics* (6th ed.). Xlibris Publishing Co., 914 pgs.

Tensar Geogrid Applications


Roads, Pavements & Surfaces


Rail Track


Walls & Slopes


Subgrade Stabilization


Environmental Construction


Scour Control


Marine Foundation Improvement


Heavy Duty Surfaces

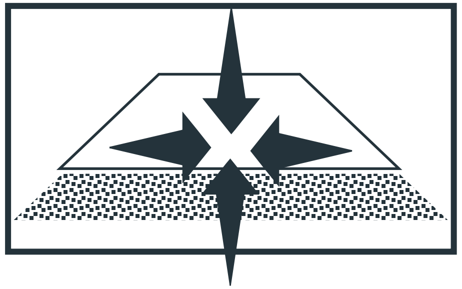

Structure Foundation Support


Underground Mining Support

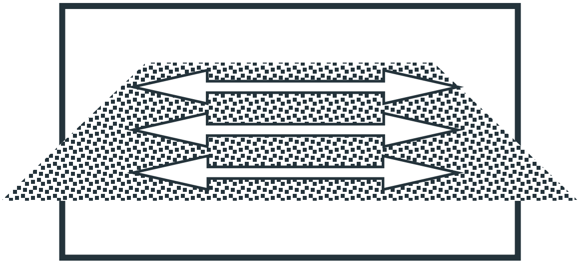

Embankments


Crane Platforms

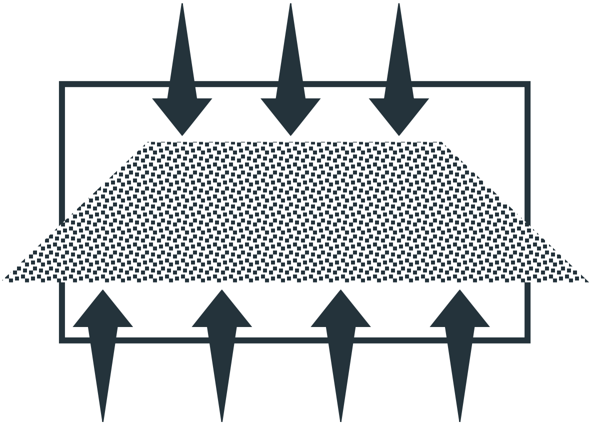
Geosynthetic functions



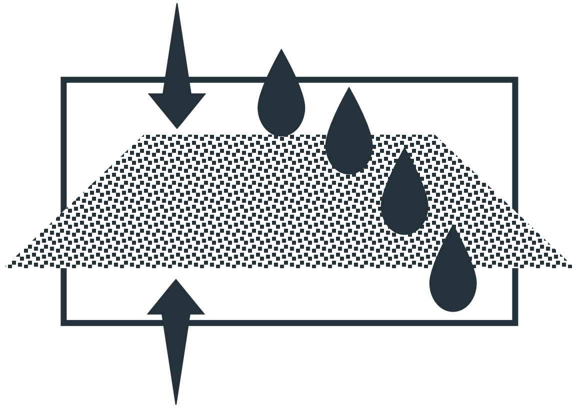
1 Stabilization



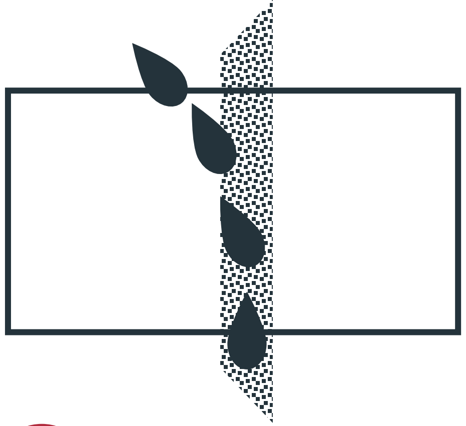
2 Reinforcement



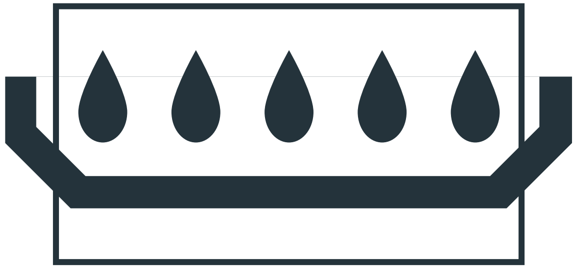
3 Separation



4 Filtration



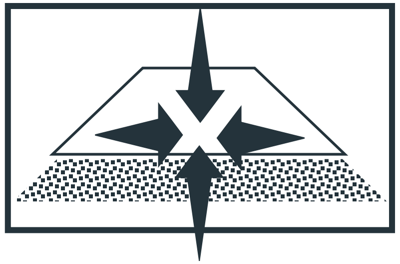
5 Drainage



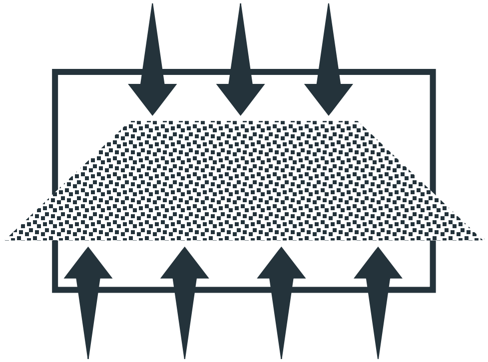
6 Containment

What are Geogrids?

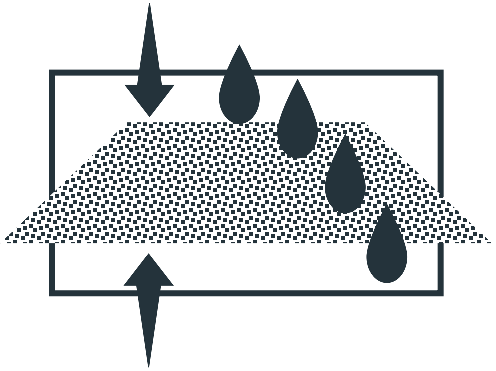
- Geogrids are used to provide the functions of:



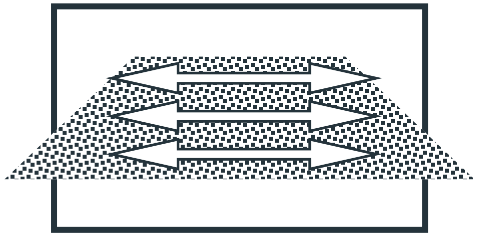
Stabilization



Separation

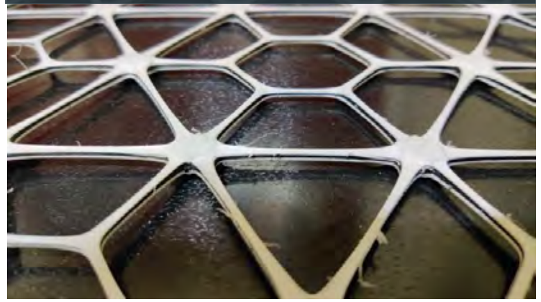


Filtration

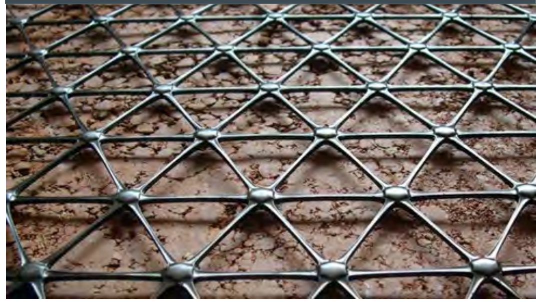


Reinforcement

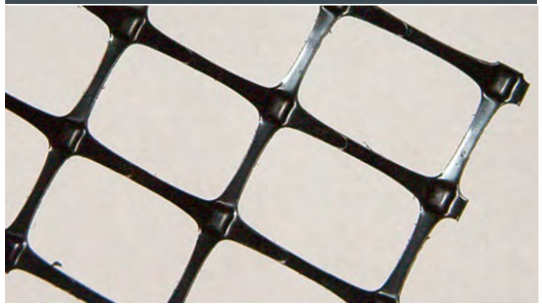
InterAx Geogrid (NX)



TriAx Geogrid (TX)



Biaxial Geogrid (BX)



Uniaxial Geogrid (UX)

What are Geogrids?

Tensar

Designing to Function

- There are many geosynthetic materials and each provides a specific function (or functions) – always start with the function to be accomplished and select materials on this basis
- Use appropriate design methodology for the proposed application
- Understand which material properties affect performance (design inputs) and which serve as QC measures only
- Many design methods for geosynthetics are empirically-based: make sure there is sufficient performance validation testing on the materials you specify

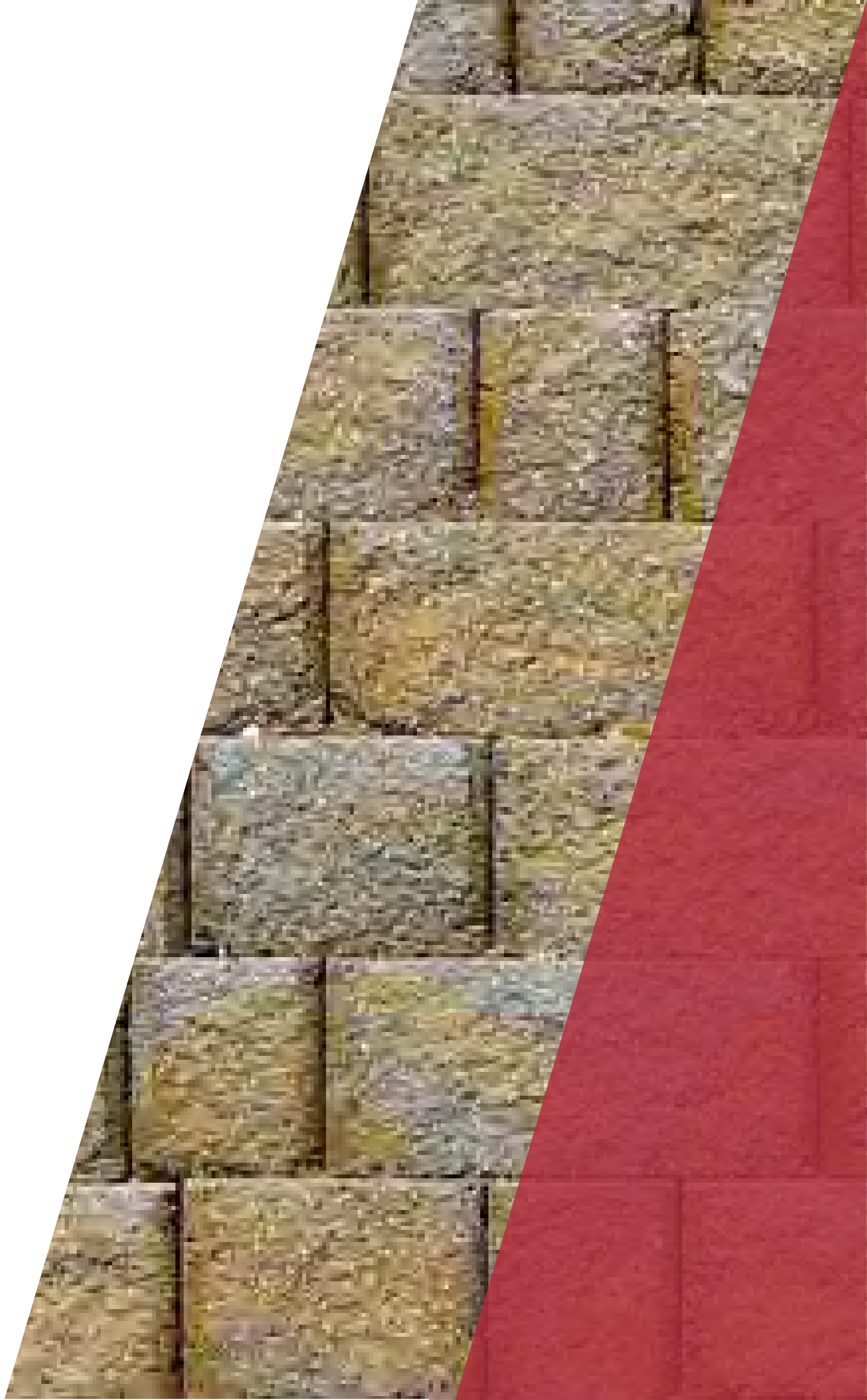
Mechanisms of Geogrids

1. Aggregate Confinement
2. Improved Bearing Capacity
3. Tension Membrane Effect

All mechanisms act together to

MAKE STONE PERFORM BETTER

These mechanisms were identified and defined by
ACE USACOE, Tngle & Webster (2003)



Subgrade Stabilization

Tensar

Options for Addressing Weak Subgrades

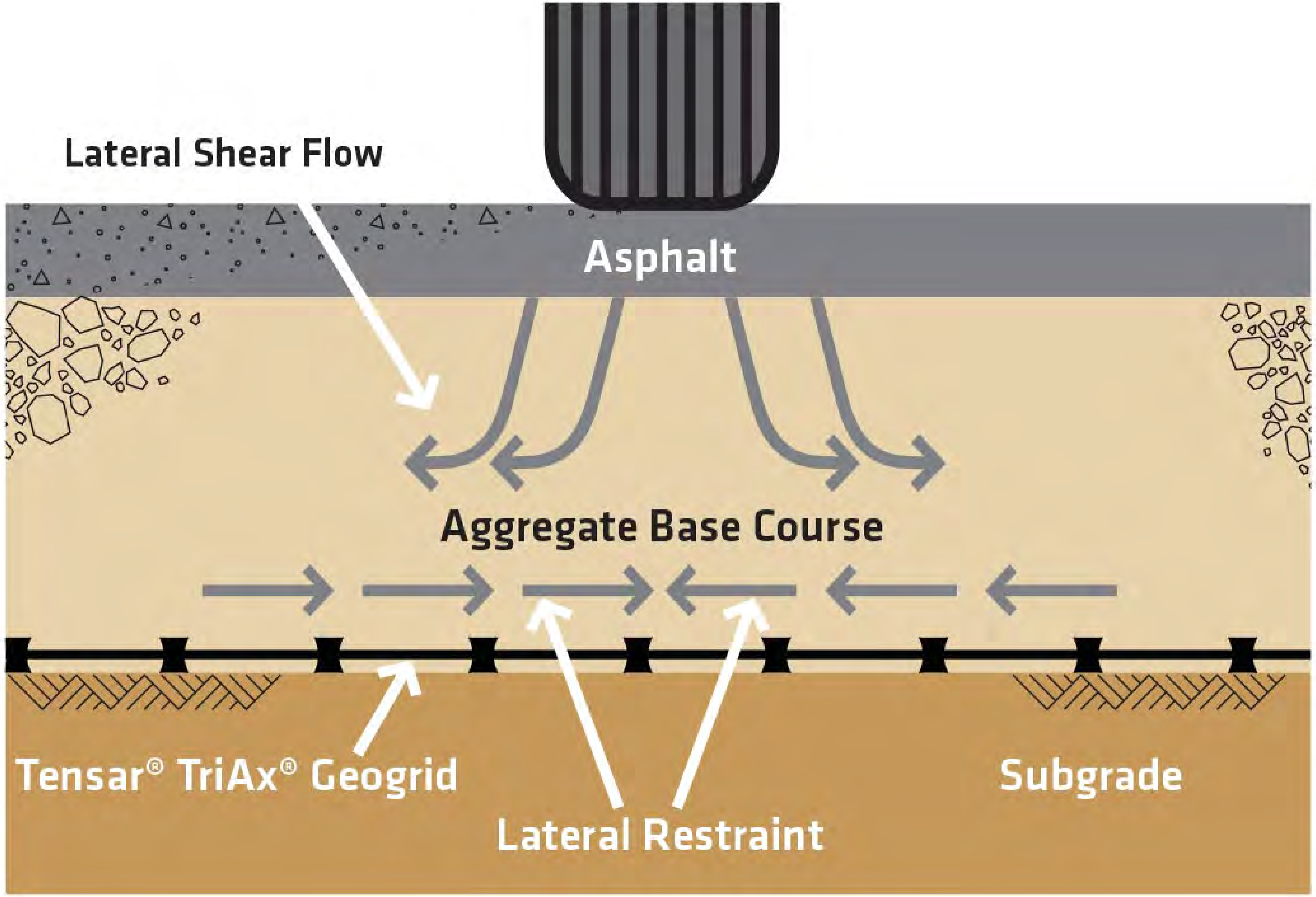
Excavate and Replace – remove the poor-quality soil and replace it with better material

Thicker Base or Sub-Base Layer – Use more granular material on top of the poor subgrade

Augment the Subgrade Soil – Use lime or other chemical treatments to improve the soil's strength

Mechanical Stabilization – Use geogrid to stabilize the subgrade

Mechanisms – Aggregate Confinement



Source: USACOE ETL 1110-1-189

County Highway D Stabilization

Wood County, MN

2014

TX160

CLIENT’S CHALLENGE

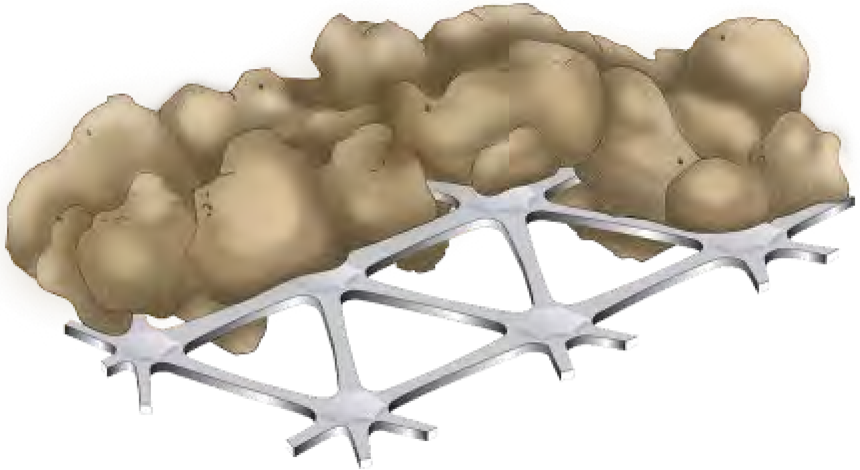
- Wood County MN had a project to repave a section of County Highway D that was being damaged by truck traffic from local cranberry bogs.
- The county needed to stabilize this very soft subgrade and had a design using 25” of aggregate.

TENSAR SOLUTION

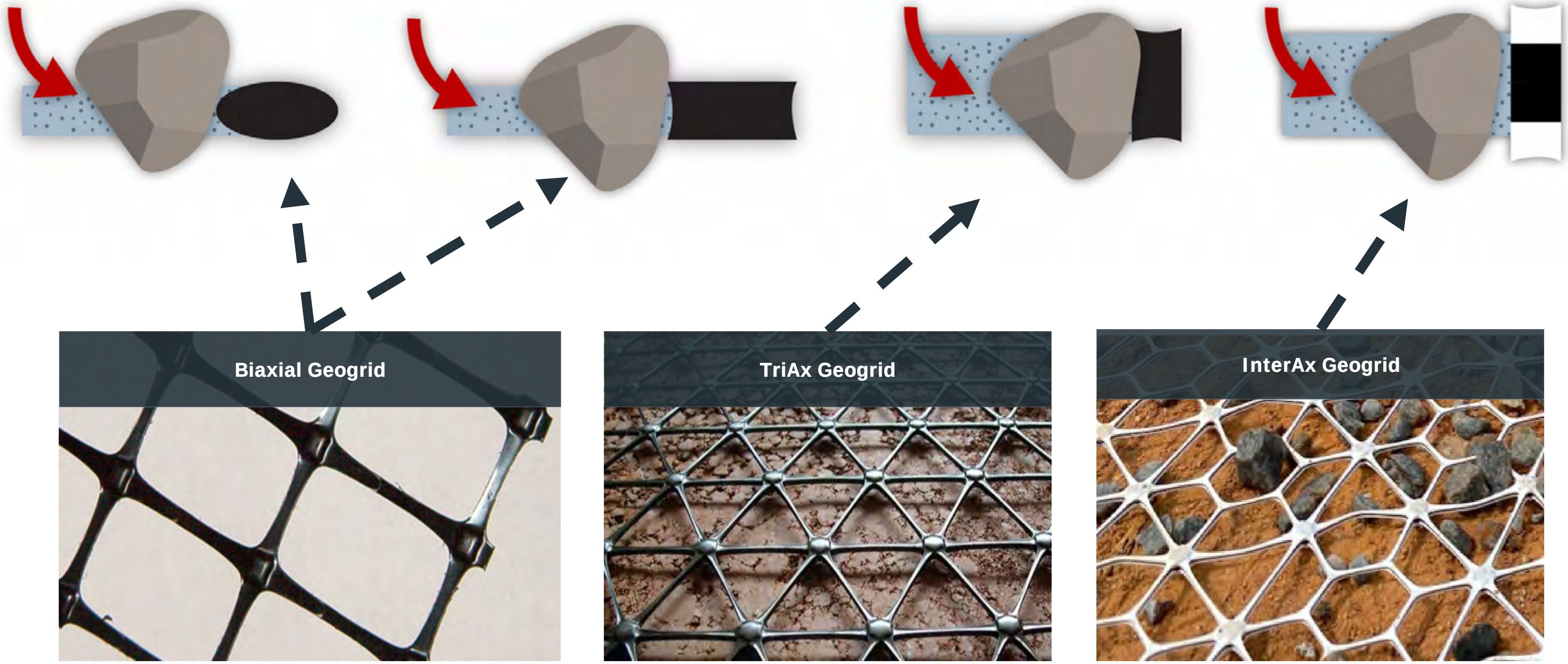
- Tensar proposed a TX160 stabilized section which allowed them to reduce the aggregate thickness from 25” to 10”, saving more than 40% on installed cost.

Tensar

Mechanisms – Aggregate Confinement

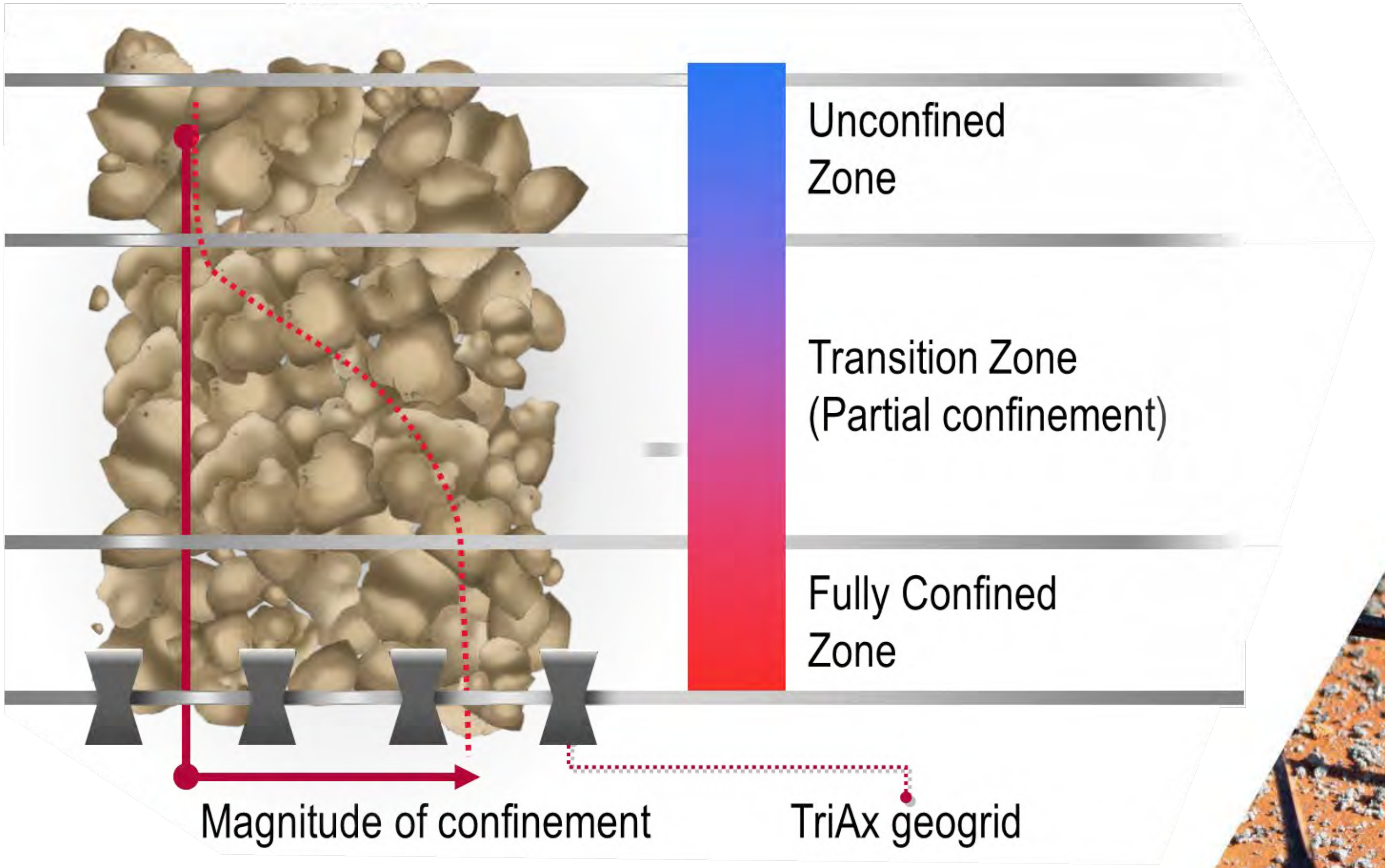


Evolution of Geogrids



Tensar

Mechanically Stabilized Layer (MSL) Concept



Small Scale Trafficking Tests (BX to TX)



Unstabilized
3,000 passes

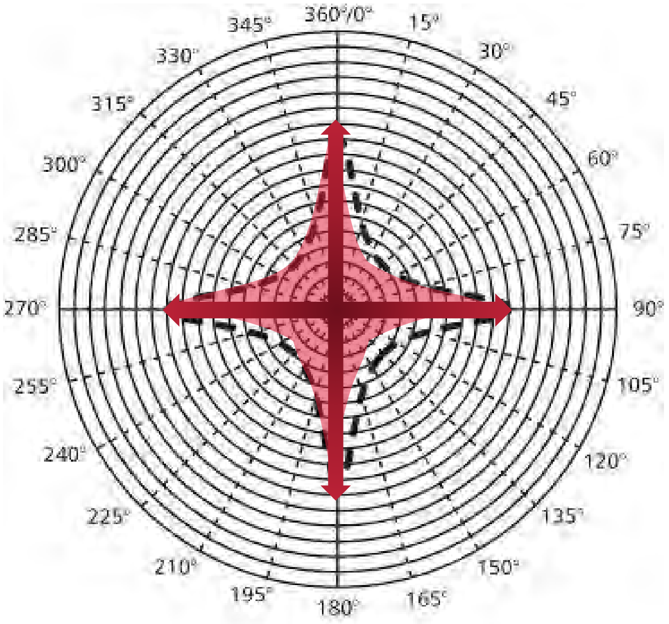
BX Geogrid
10,000 passes

TX Geogrid
10,000 passes



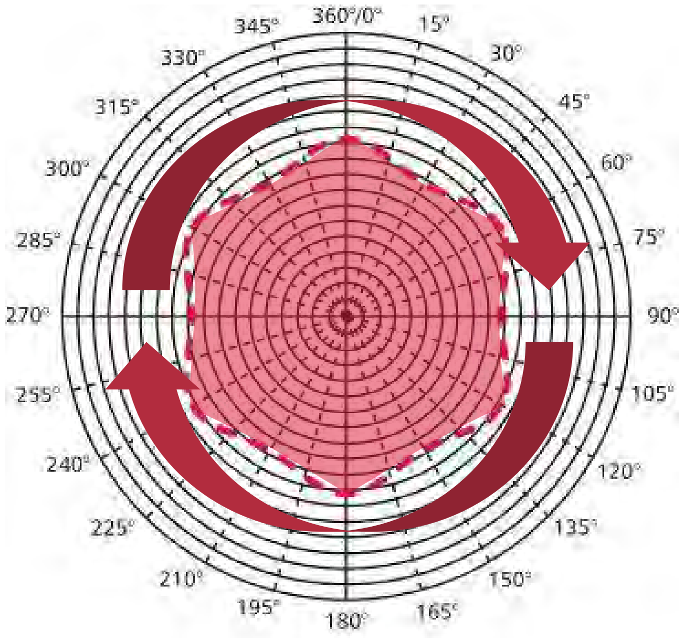
Mechanisms – Improved Bearing Capacity

BiAx



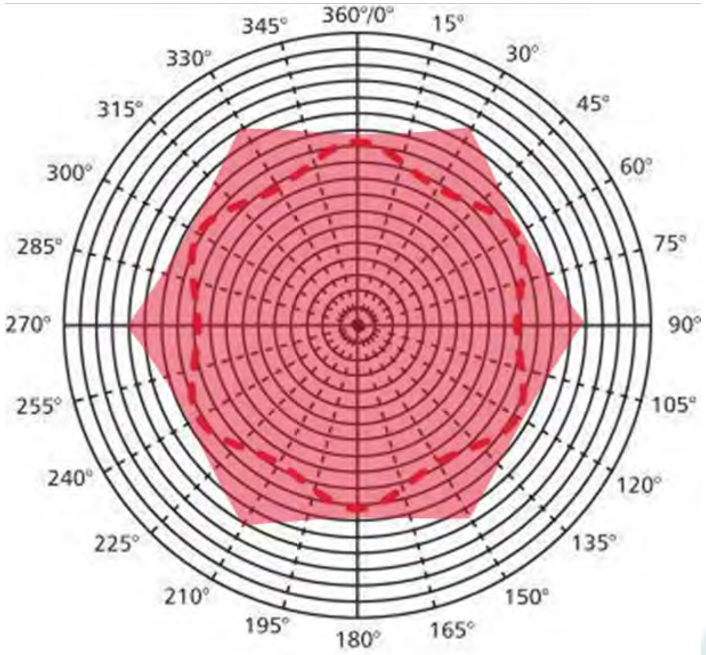
STIFFNESS

TriAx



STIFFNESS

InterAx



STIFFNESS

Improved Bearing Capacity in Action

Tensar

Mechanisms – Tensioned Membrane Effect

Geogrids don't require on-site tensioning, allowing for immediate support once a designed stone thickness is met.

Geotextile relies only on the hammock effect. Vertical support is only achieved through rutting in the subgrade.

Designing to Function

- There are many geosynthetic materials and each provides a specific function (or functions) – always start with the function to be accomplished and select materials on this basis
- Use appropriate design methodology for the proposed application
- Understand which material properties affect performance (design inputs) and which serve as QC measures only
- Many design methods for geosynthetics are empirically-based: make sure there is sufficient performance validation testing on the materials you specify

Pavement Optimization

SW116th Ave Pavement Optimization

Fayette, ND

2014 - 2016

TX7 (~ 400,000 SY over 3 phases)

CLIENT’S CHALLENGE

- Due to heavy oil and agricultural traffic, Dunn County (ND) had a project to rebuild 29 miles of SW 116th Avenue SW, converting from an unpaved to paved surface.
- The original, unstabilized pavement design called for 6” of ACC, over 12” of aggregate base course (ABC), over 12” of cement treated subgrade.

TENSAR SOLUTION

- Tensar performed a pavement optimization analysis and proposed a TX7 geogrid, which would allow the county to reduce their aggregate base course from 12” to 6”. While maintaining the required ESAL rating of 2.7M.
- At $40/ton for ABC, this 50% reduction in layer thickness saved the county over $160,000 in material costs per mile of road.

Tensar

AASHTO 93 and Structural Numbers (SN)

$$\log_{10}(W_{18}) = Z_R S_o + 9.36\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\log_{10} M_R - 8.07$$

W_{18} = Allowable ESALs

Z_R = Standard normal deviate

S_o = Standard deviation

SN = Structural number

ΔPSI = Change in serviceability

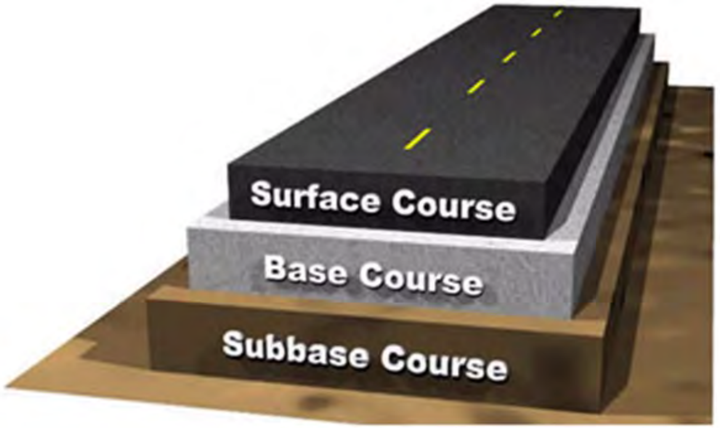
M_R = Subgrade resilient modulus

- Converted to a layer depth using coefficients.
  - SN = a_1D_1 + $\mathbf{a_2}$*****D_2m_2 + $a_3D_3m_3$ + …

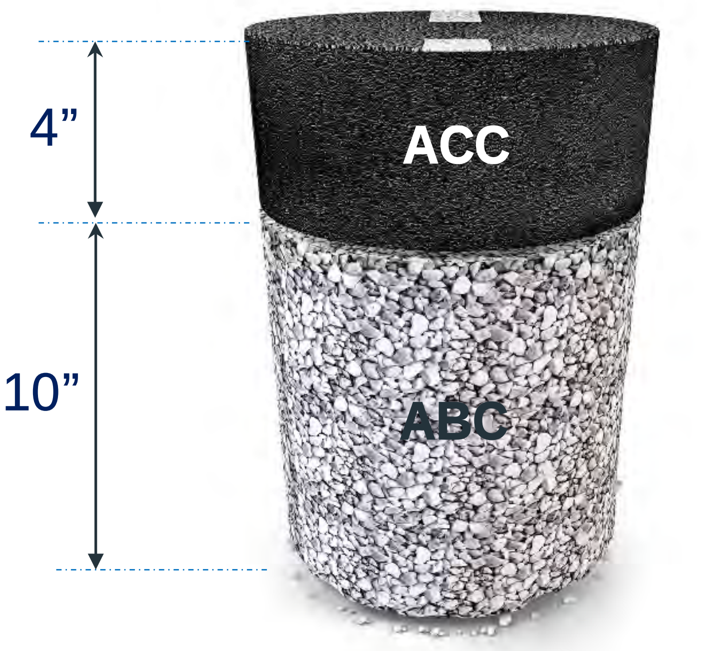
a = **ENHANCED (base)** structural layer coefficient

D = layer thickness (inches)

m = layer drainage coefficient (typ. 1.0)



Pavement Optimization Example



Structural Number

a = 0.40

SN = (0.40) x (4.0) = 1.60

a = 0.14, m = 1.0

SN = (0.14) x (10.0) x (1.0) = 1.40

Overall SN = 1.60 + 1.40 = 3.00

Calculate SN and ESAL Rating

$$\log_{10}(W_{18}) = Z_R S_o + 9.36\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\log_{10} M_R - 8.07$$

W_{18} = Allowable ESALs

Z_R = Standard Normal Deviate = -1.645 (for 95% reliability)

S_0 = Standard Deviation = 0.49

SN = Structural Number = 3.00

ΔPSI = Change in Serviceability = 4.0 – 2.0 = 2.2

M_R = Subgrade Resilient Modulus = 5,000 psi

W_{18} = 117,000 ESALs (Unstabilized)

Tensar

What is an ESAL?

The most commonly used equivalent load in the U.S. is the 18,000 lb. (80 kN) "**E**quivalent **S**ingle **A**xle **L**oad" - normally designated **ESAL**.

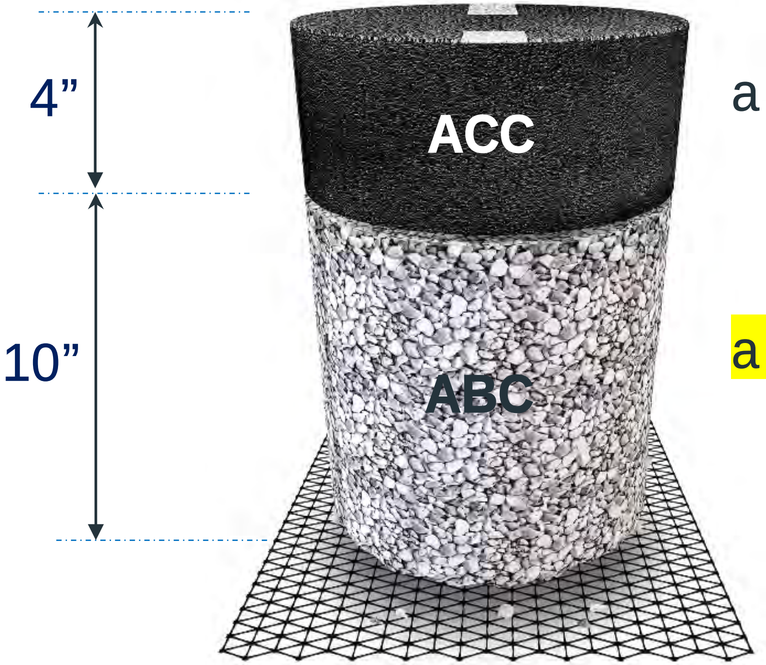
45,000 lb. loaded dump truck
- One single axle
- Two dual axles
- Total ESAL ~ 2.4

4,000 lb. SUV
- Two single axles
- Total ESAL ~ 0.0006

1 dump truck is equal to roughly 4,000 SUVs

https://pavementinteractive.org/reference-desk/design/design-parameters/equivalent-single-axle-load/

Enhanced Layer Coefficient



TX5 Geogrid

Structural Number

a = 0.40

SN = (0.40) x (4.0) = 1.60

a = 0.23, m = 1.0

SN = (0.23) x (10.0) x (1.0) = 2.30

Overall SN = 1.60 + 2.30 = 3.90

Enhanced Structural Number Calculations

$$\log_{10}(W_{18}) = Z_R S_o + 9.36\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\log_{10} M_R - 8.07$$

W_{18} = Allowable ESALs

Z_R = Standard Normal Deviate = -1.645 (for 95% reliability)

S_0 = Standard Deviation = 0.49

SN = Structural Number = 3.90

ΔPSI = Change in Serviceability = 4.0 – 2.0 = 2.2

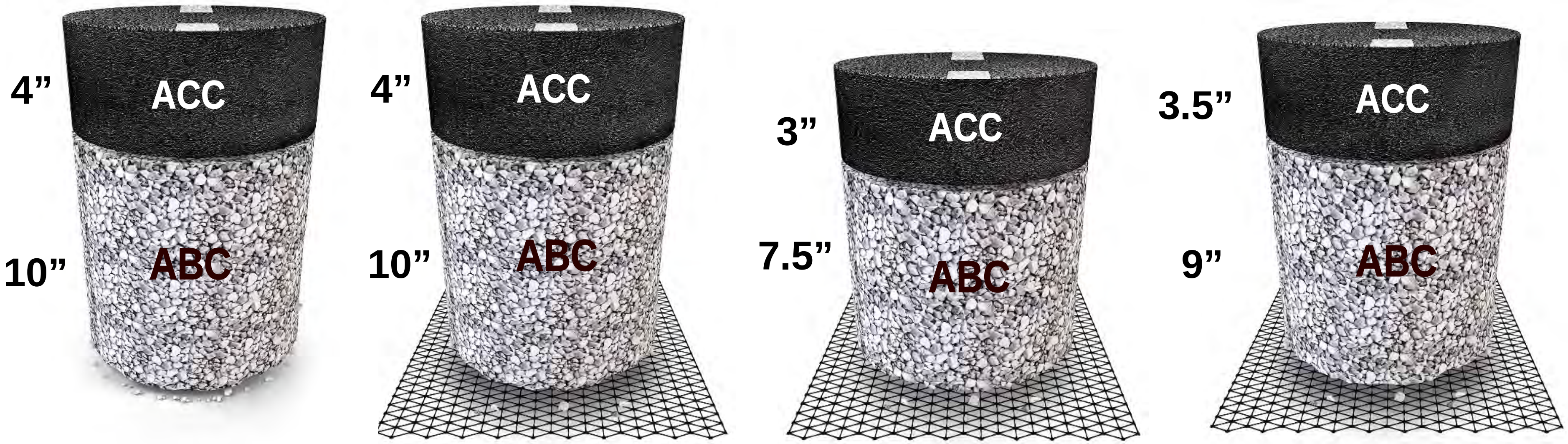
M_R = Subgrade Resilient Modulus = 5,000 psi

W_{18} = 686,000 ESALs (Stabilized using TX geogrid)

Tensar

Comparisons of Enhanced Pavement Designs

Proposed Design Unstabilized	Lowest Life Cycle Cost	Lowest Initial Cost	Same Initial Cost



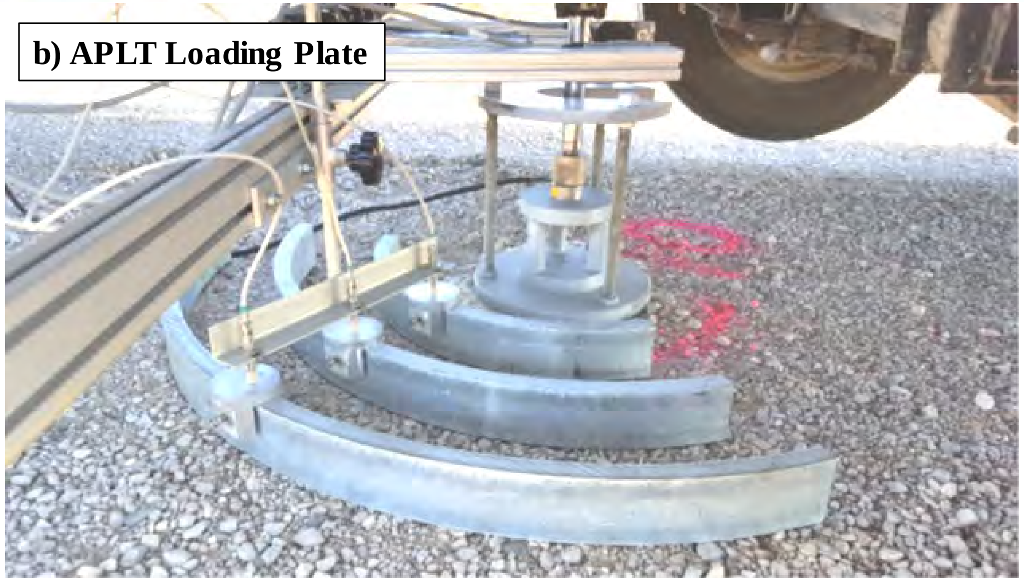
	TX5 Geogrid	TX5 Geogrid	TX5 Geogrid
117,000 ESALs	**686,000 ESALs**	**120,000 ESALs**	**349,000 ESALs**
	586% life extension	**1.03% life extension**	**298% life extension**

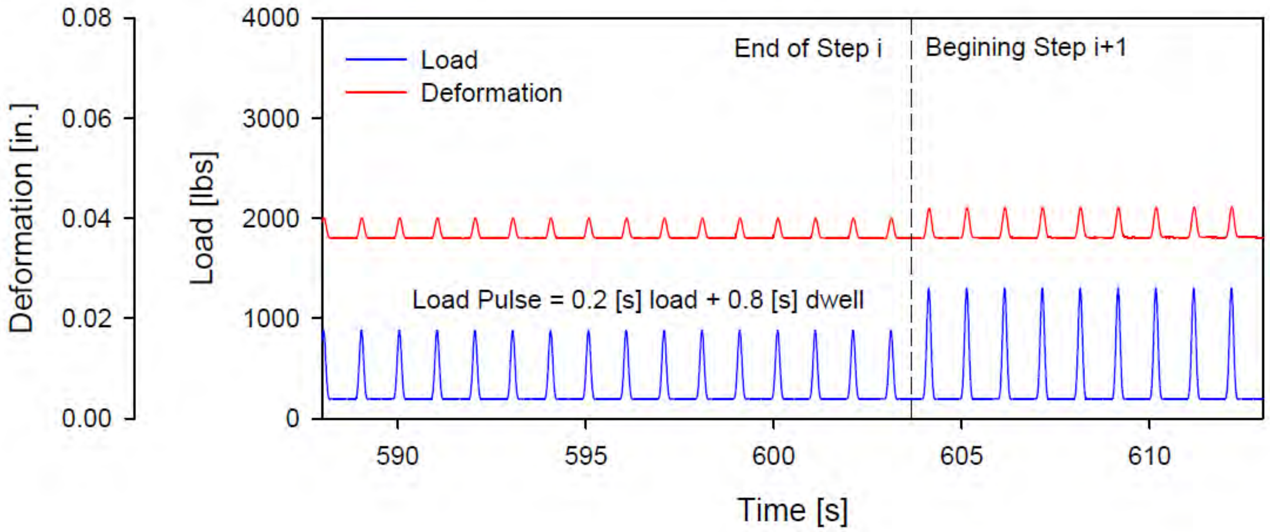
Tensar

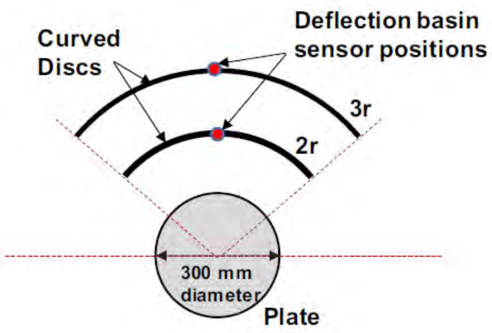
Full Scale Accelerated Pavement Testing (APT)

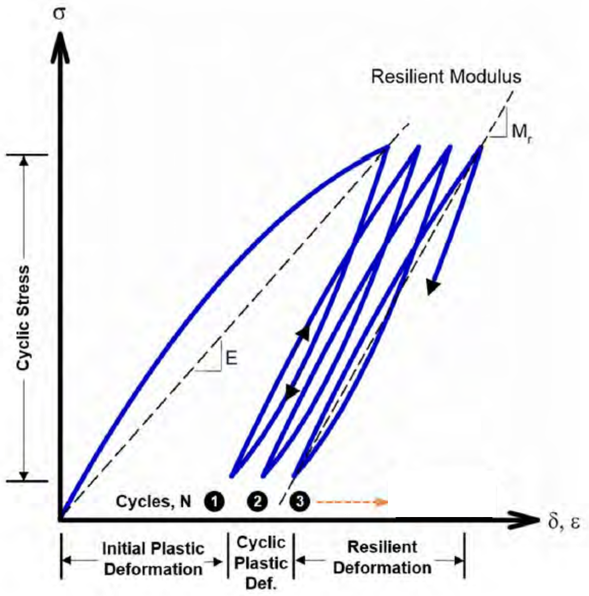
ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

Field Validation: APLT (Automated Plate Load Testing)









APLT – In situ Verification

Research Organization

Ingios Geotechics, Inc.

Geosynthetic Type

TX5

Testing Conducted

Mr of the mechanically stabilized base course

Mr of the subgrade

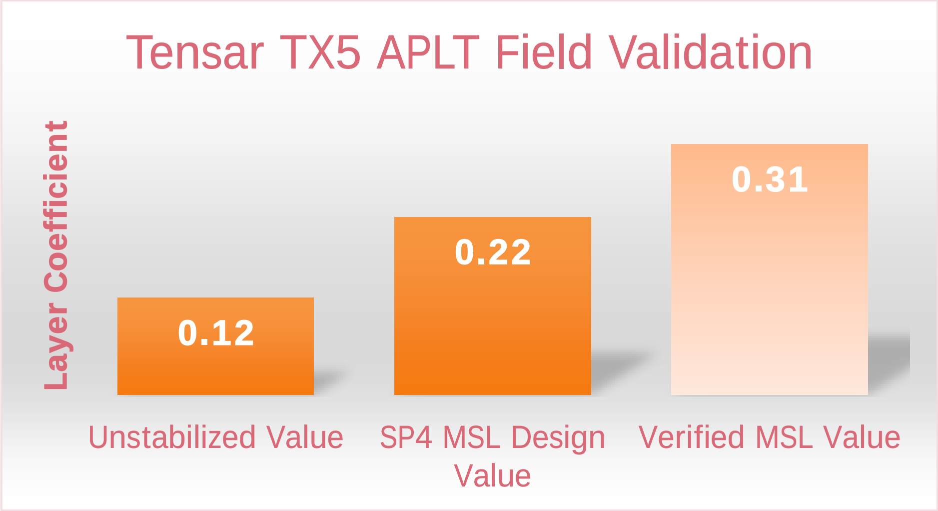
Mr composite modulus

Modulus of subgrade reaction (k)

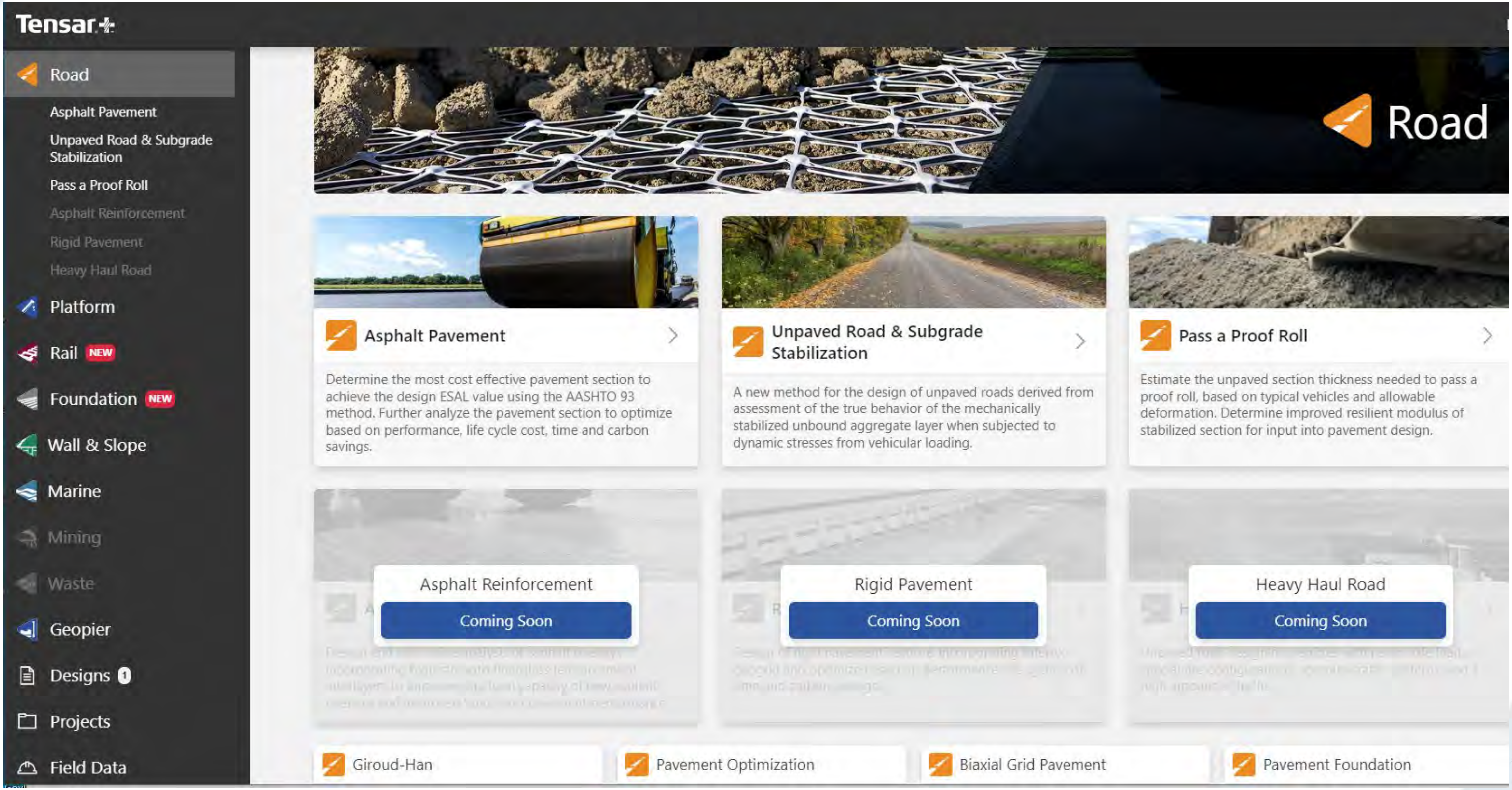
ev1 and ev2 strain modulus testing

Resilient deflections (scaling exponent)

Mr (Ave) base	155,694 psi
Mr (Ave) subgrade	16,144 psi
Mr (Ave) composite	34,251 psi
Ev2 (top of stabilized base)	15.23 ksi
Ev2/Ev1 Ratio	1.60
K-value (stabilized)	392 pci

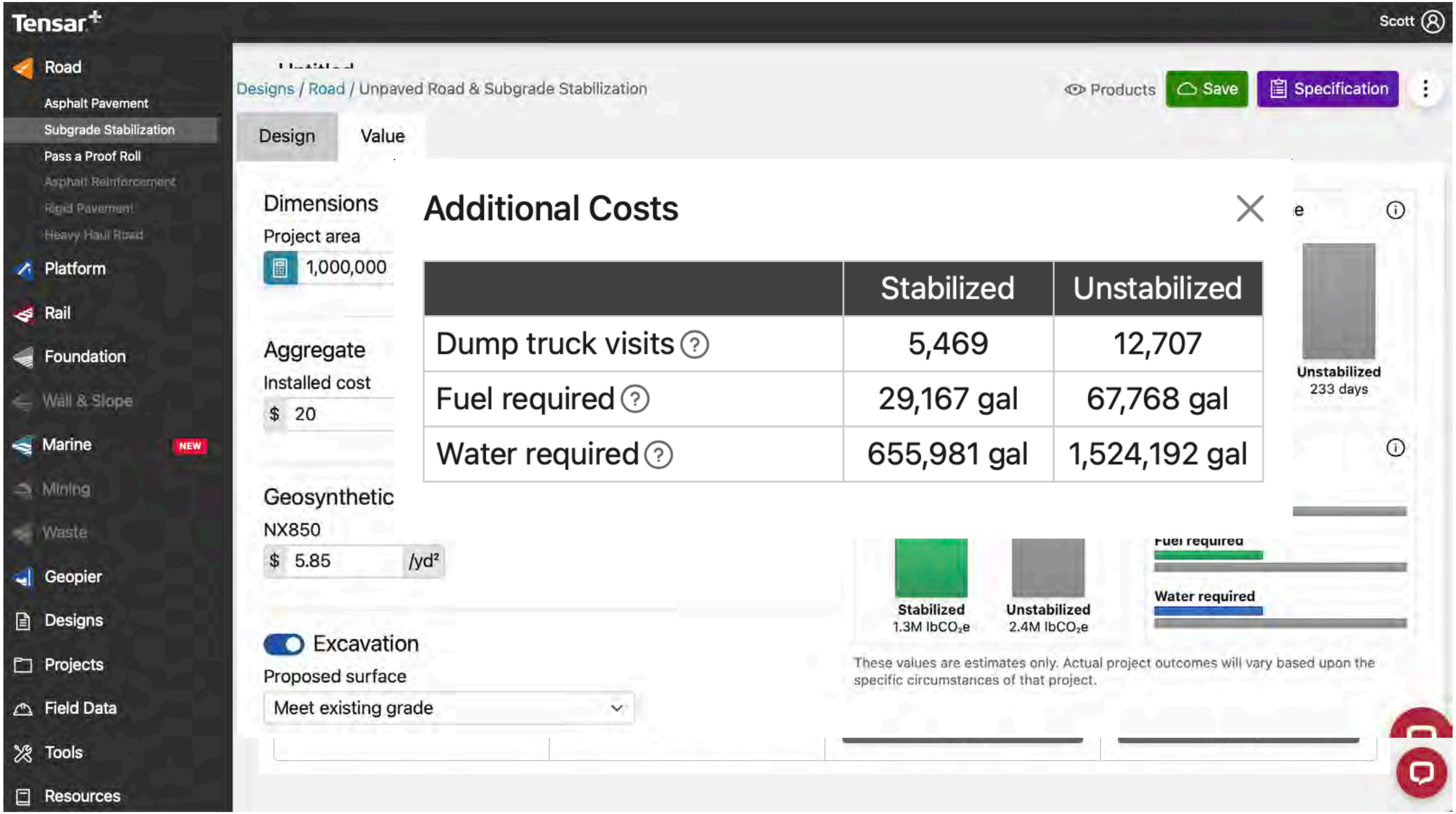


New / Upgraded Design Methods



Tensar

Tensar+



	Stabilized	Unstabilized
Dump truck visits	5,469	12,707
Fuel required	29,167 gal	67,768 gal
Water required	655,981 gal	1,524,192 gal

Tensar.

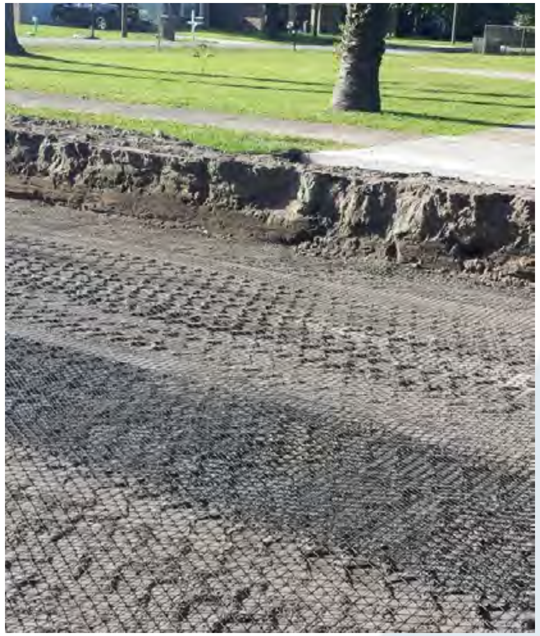
Local Projects in Florida:

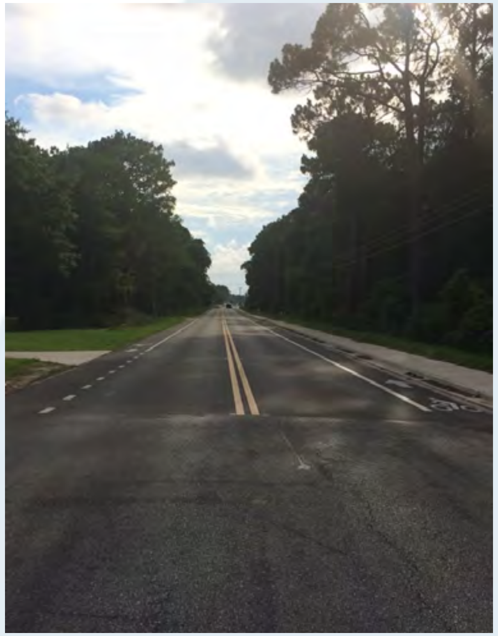
Brief Overview of Local Tensar Solutions

Baldwin Road Reconstruction in Bay County, FL

- Pavement structure was resurfaced periodically, but continued to deteriorate
- Geotechnical investigation revealed 7.5” to 13” of existing asphalt
- Very soft organic material existed at different depths under the road

Baldwin Road Reconstruction in Bay County, FL





- Two-layer system to mitigate issues caused by organic layer
- Lower layer used to minimize undercut, bridge over soft material, and to stabilize subgrade
- Upper layer used to improve road traffic capacity and to minimize aggregate and asphalt thickness

Jenks Avenue Widening in Panama City, FL

- Widening of a road from 22’ to 63’ on either side of the existing lanes
- Geotechnical investigation showed organic soils 2’ to 8’ thick underneath the area used for the lane widening
- Shallow groundwater and underground utilities
- The existing road could not be undermined, and excavation needed to be kept to a minimum

Jenks Avenue Widening in Panama City, FL

- Two-layer system to mitigate issues caused by organic layer, shallow groundwater and utilities

- Lower layer used to minimize undercut, and bridge over soft material

- Upper layer used to improve road traffic capacity and to minimize aggregate and asphalt thickness

PK Avenue Reconstruction in Auburndale, FL

- Reconstruction of a city road
- Needed to eliminate Type B Stabilization (LBR 40) due to shallow utilities underneath the road
- Impossible to do mechanical mixing
- Lower layer of geogrid helped minimize excavation and protect the utilities

PK Avenue Reconstruction in Auburndale, FL

Residential Road Construction in Groveland, FL

Access Road in Orlando, FL

Fire Access Road in Ponte Vedra, FL

Receive Your Electronic PDH

Select Course #101

Thank You!

pschmitz@tensarcorp.com

Tensar