State-of-Practice on the Use of Geosynthetics in Roadway Applications

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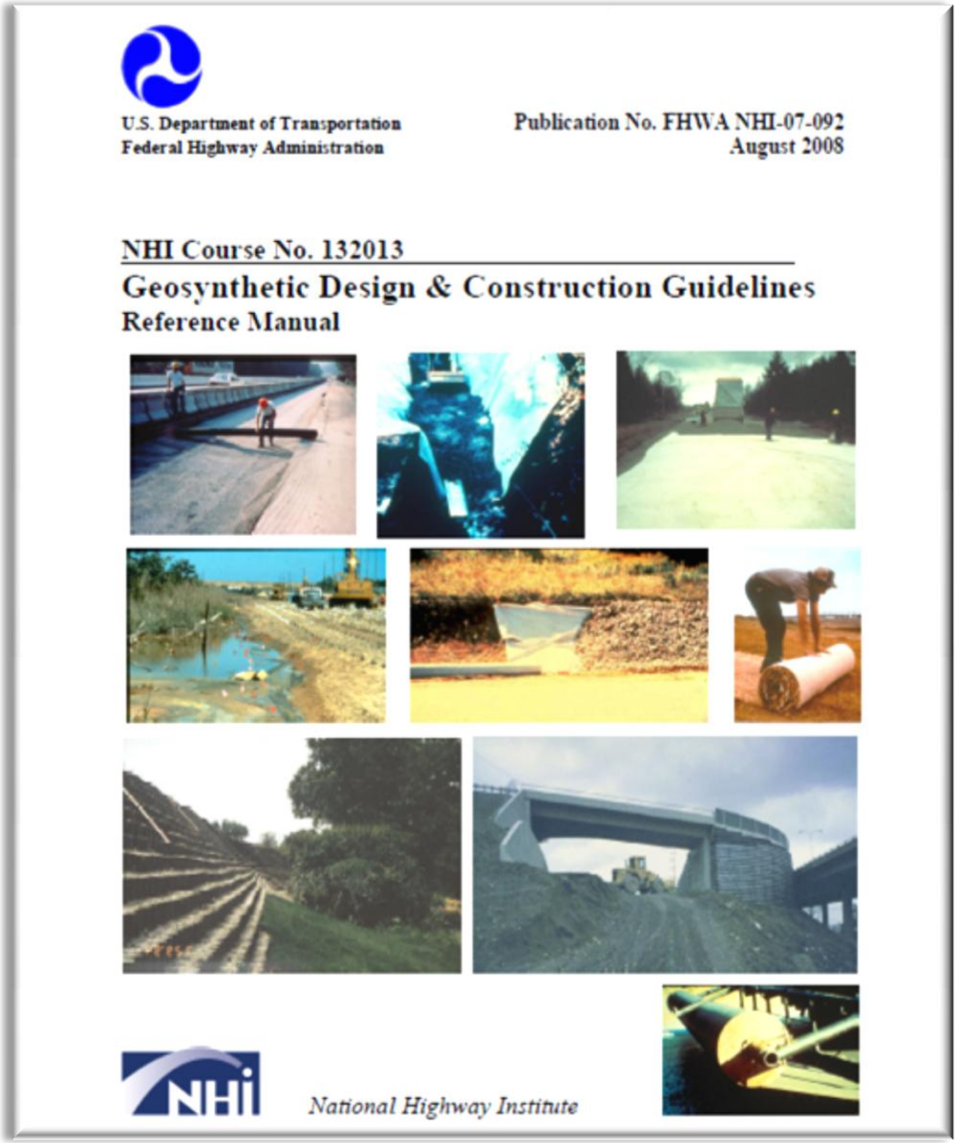
30+ YEARS
Foundation & Pavement
Optimization

FEDERAL HIGHWAY ADMINISTRATION

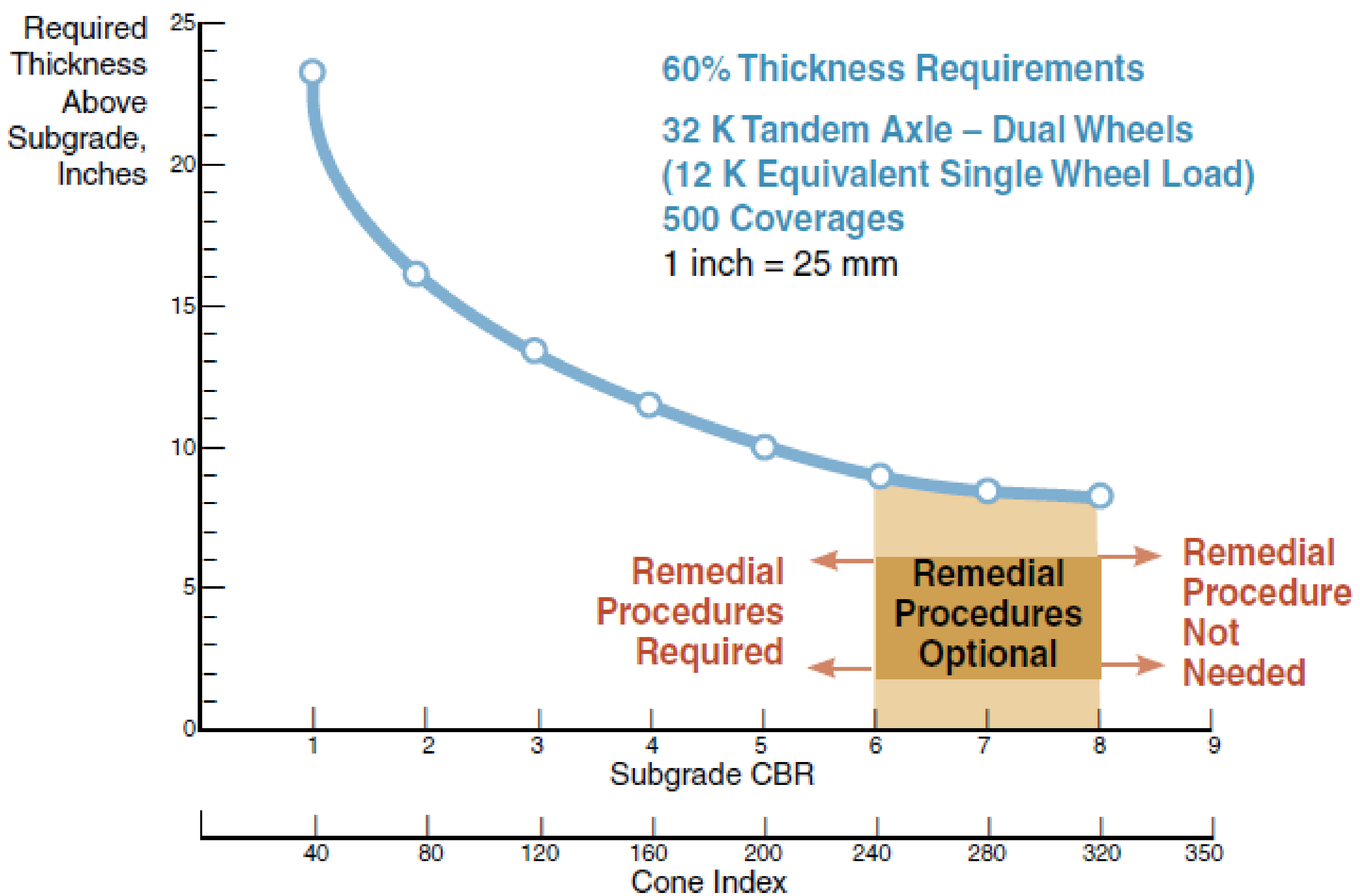


Why Geogrids?

Flexible Pavement Design

- Construction Platform
- Paved Road

(IDOT, 1982)

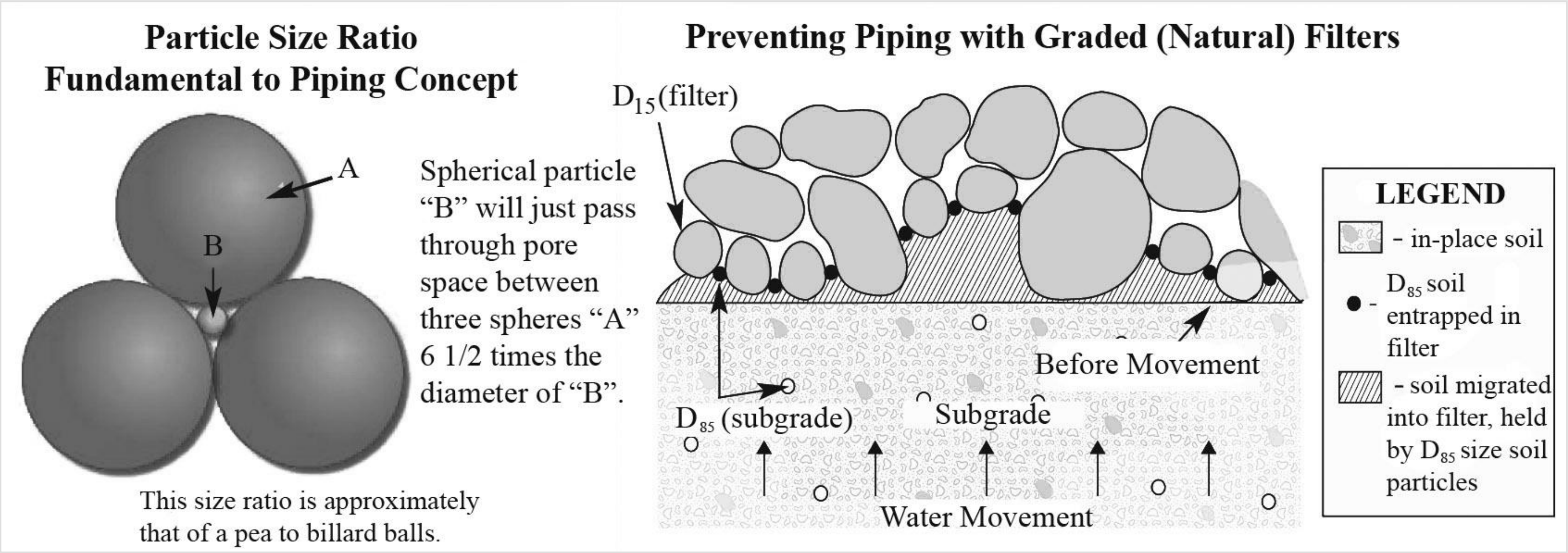


12” PennDOT 2A Mod.
Traffic Course Geogrid
12” PennDOT 2A Mod.
Subgrade Stabilization Geogrid
BEFORE

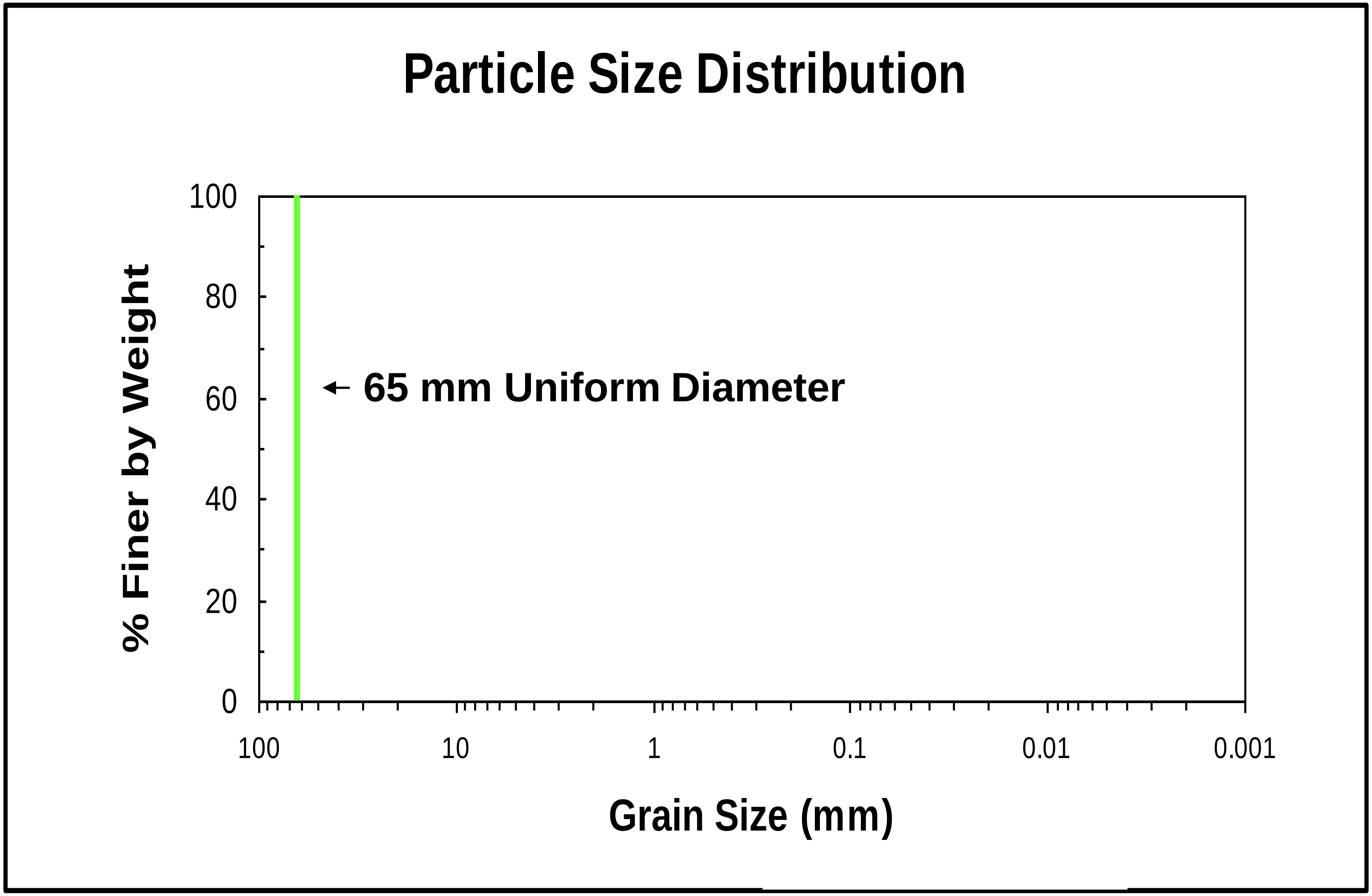

AFTER


SEPARATION

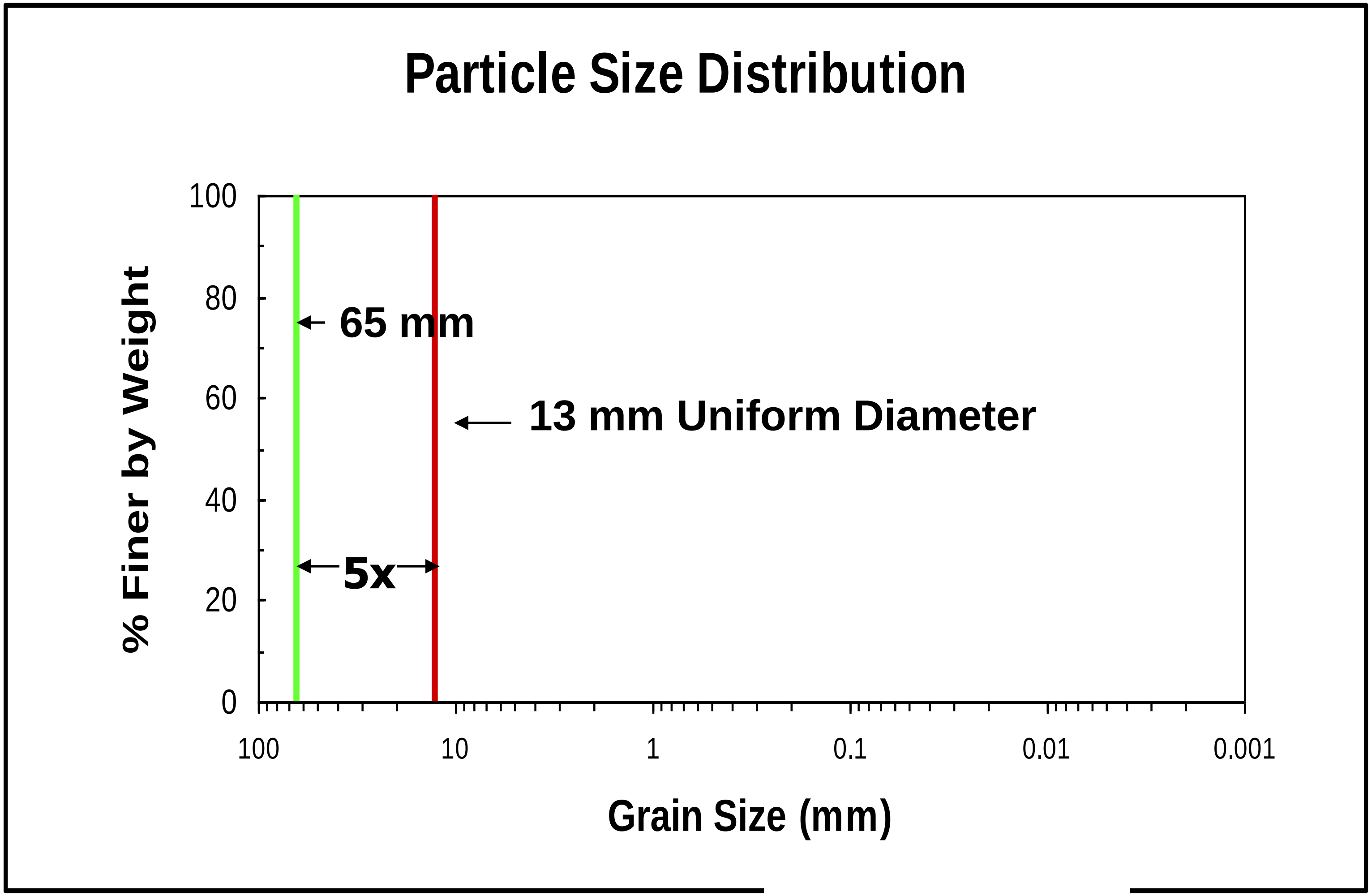
Interface Immobilization



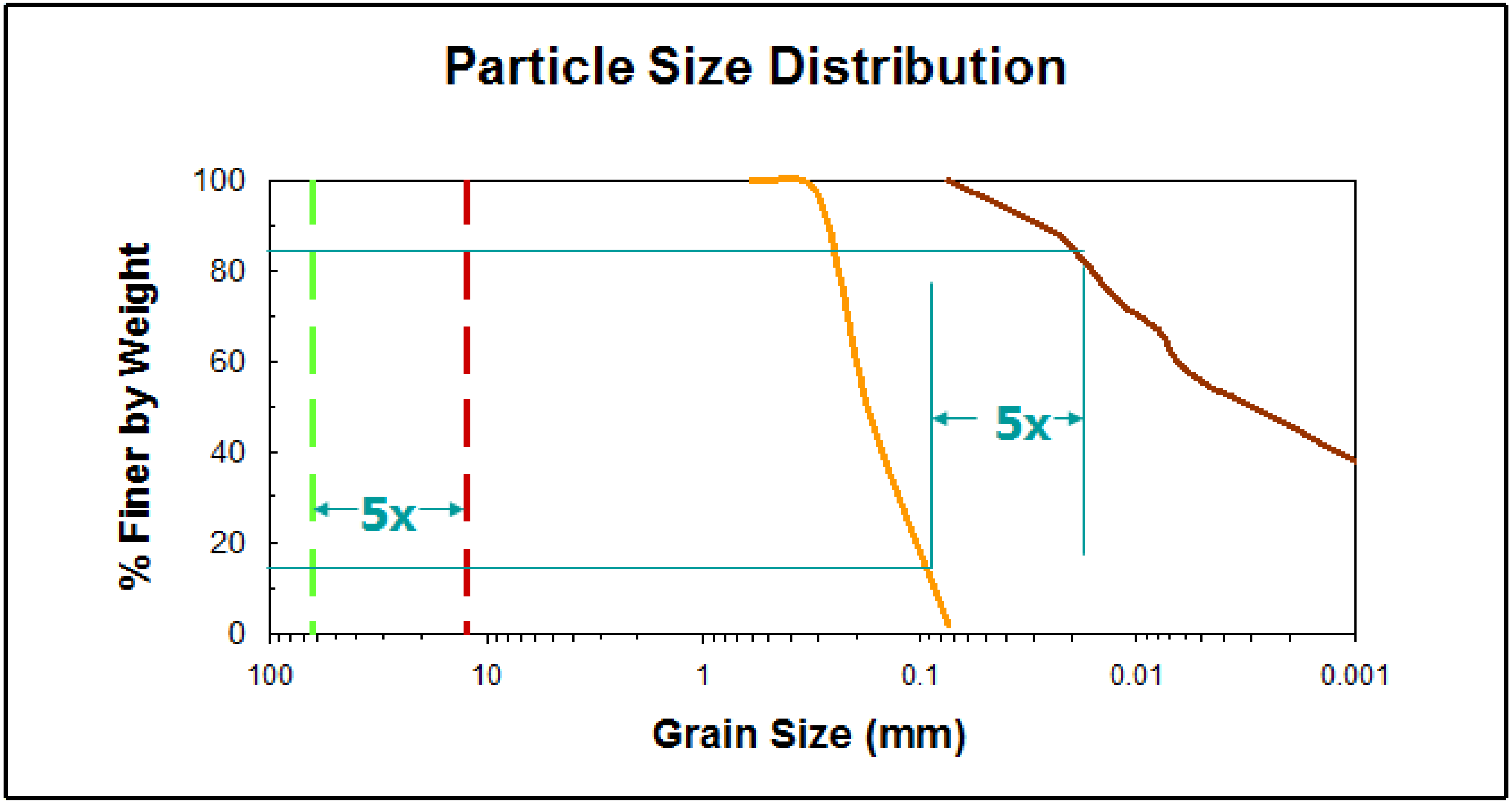
A Sieve Analysis of Tennis Balls…



… and also Marbles



Subgrade Particles Cannot Infiltrate Aggregate Fill Just as Marbles Cannot Infiltrate Tennis Balls, Provided They Don't Move.



Filter Criteria

- **For Clayey Subgrades**:

$$\text{Piping Ratio} = \frac{D15_f}{D85_s} < 5$$

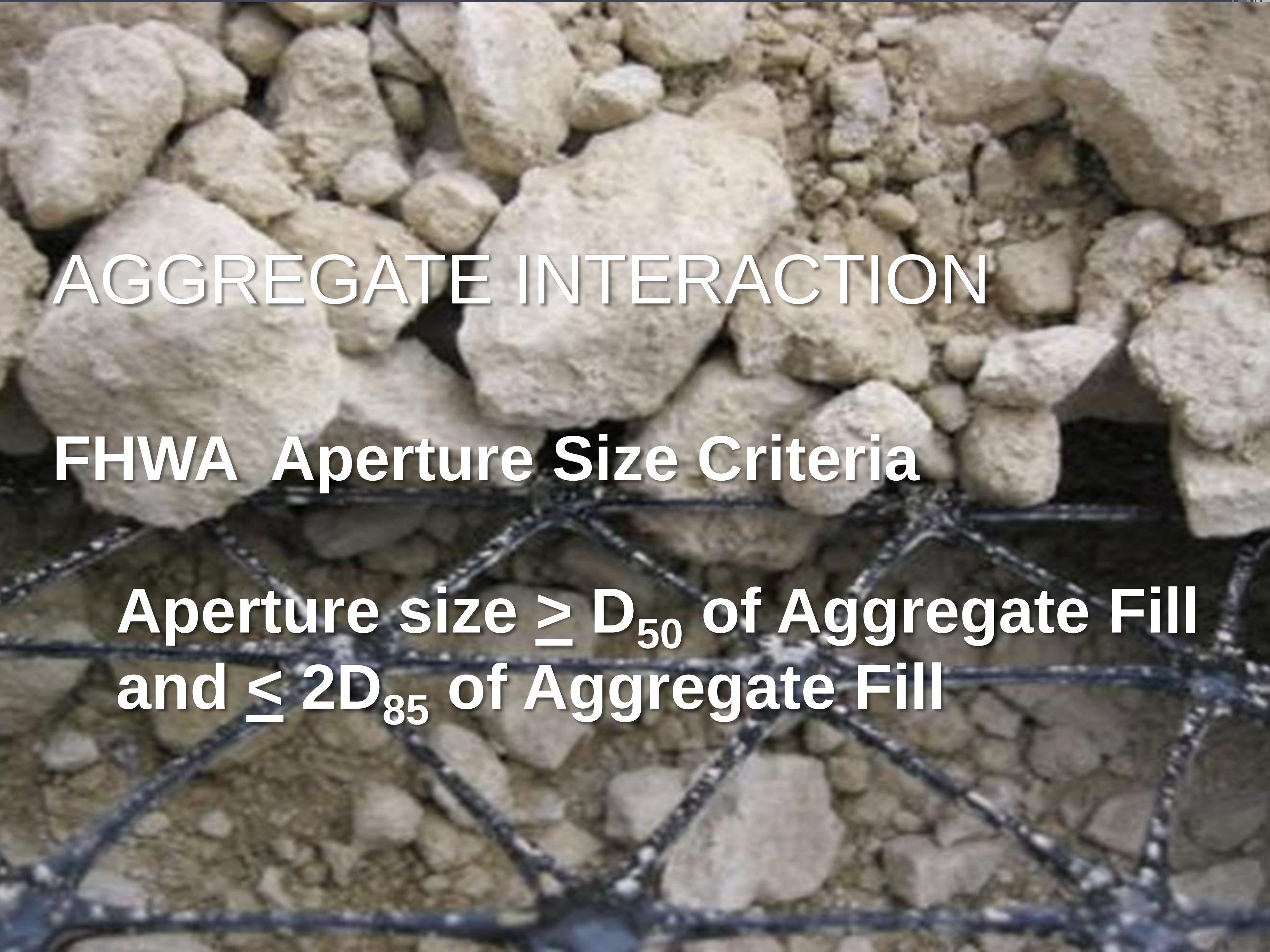
- **For Silty Subgrades**:

$$\text{Piping Ratio} = \frac{D15_f}{D85_s} < 5$$

$$\text{Average Size Ratio} = \frac{D50_f}{D50_s} < 25$$

So if Water is Present and Filter Criteria are Not Satisfied…

- (1) Consider an Alternative (i.e. Sandier) Aggregate Fill, at Least for the First Lift.
- (2) Consider a Nonwoven Geotextile Beneath the Geogrid, but Only if the Subgrade is Not Silty.



AGGREGATE INTERACTION

FHWA Aperture Size Criteria

Aperture size $\geq$ D_{50} of Aggregate Fill and $\leq$ $2D_{85}$ of Aggregate Fill

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Geosynthetics

PART 1 | **Method development and calibration**

The Giroud-Han design method for geosynthetic-reinforced unpaved roads

By J.P. Giroud and Jie Han

UNPAVED ROAD DESIGN

The following design equation for base course thickness was developed through calibration and verification with laboratory and field data (Giroud and Han, 2004b):

$$h = \frac{0.868 + (0.661 - 1.006J^2)\left(\frac{r}{h}\right)^{1.5} \log N}{\left[1 + 0.204(R_E - 1)\right]} \left(\sqrt{\frac{\frac{P}{\pi r^2}}{\frac{s}{f_s}\left[1 - 0.9e^{-\left(\frac{r}{h}\right)^2}\right] N_c f_c CBR_{sg}}} - 1 \right) r \qquad (1)$$

Full Scale Testing Required to Calibrate and Validate

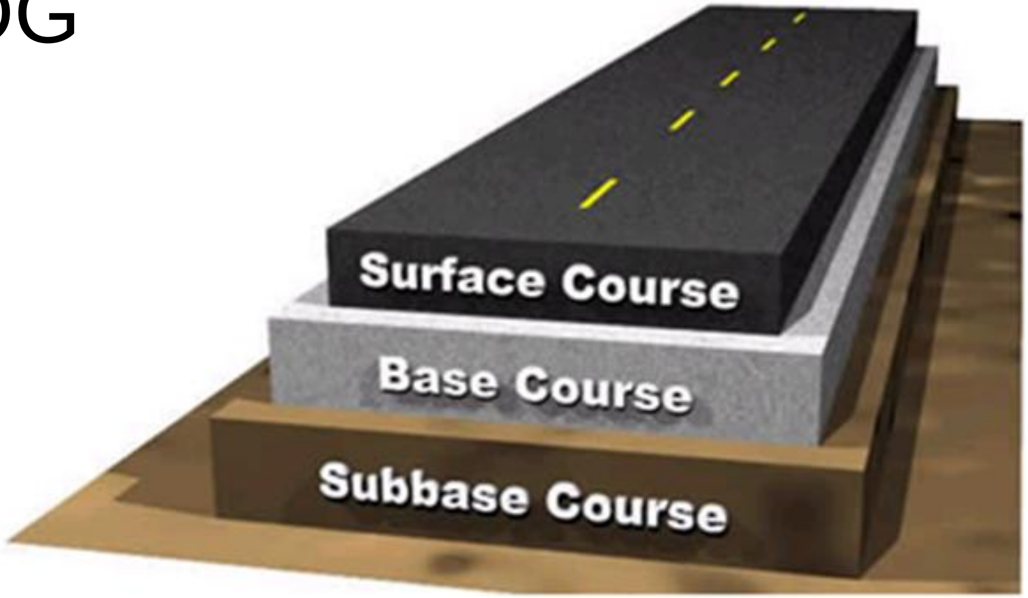
- FHWA Separation Criteria (Piping Ratio)
  - D15 fill = 0.15mm
  - D85 subgrade = 0.35mm
  - D15/D85 = 0.43<5 OK

- Average Size Ratio
  - D50fill = 3mm
  - D50subgrade=0.1mm
  - D50fill/D50subgrade=30 not < 25 but close and still worked fine for the SM used in this study.

- FHWA Aperture Size Criteria (Interaction)
  - Aperture size ≥ D50 of GAB (3mm) and ≤ 2D85 of GAB
  - **TX130S** – **22 mm** ≥3 mm OK and ≤ 2*18 or 36mm OK
  - **BX1100** – **25mm**/33mm > 3mm OK and ≤ 2*18 or 36mm OK

PAVED ROAD DESIGN

AASHTO '93
MEPDG



AASHTO STANDARD PRACTICE

Standard Practice for

Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures

AASHTO Designation: R 50-09[1]

AASHTO 93

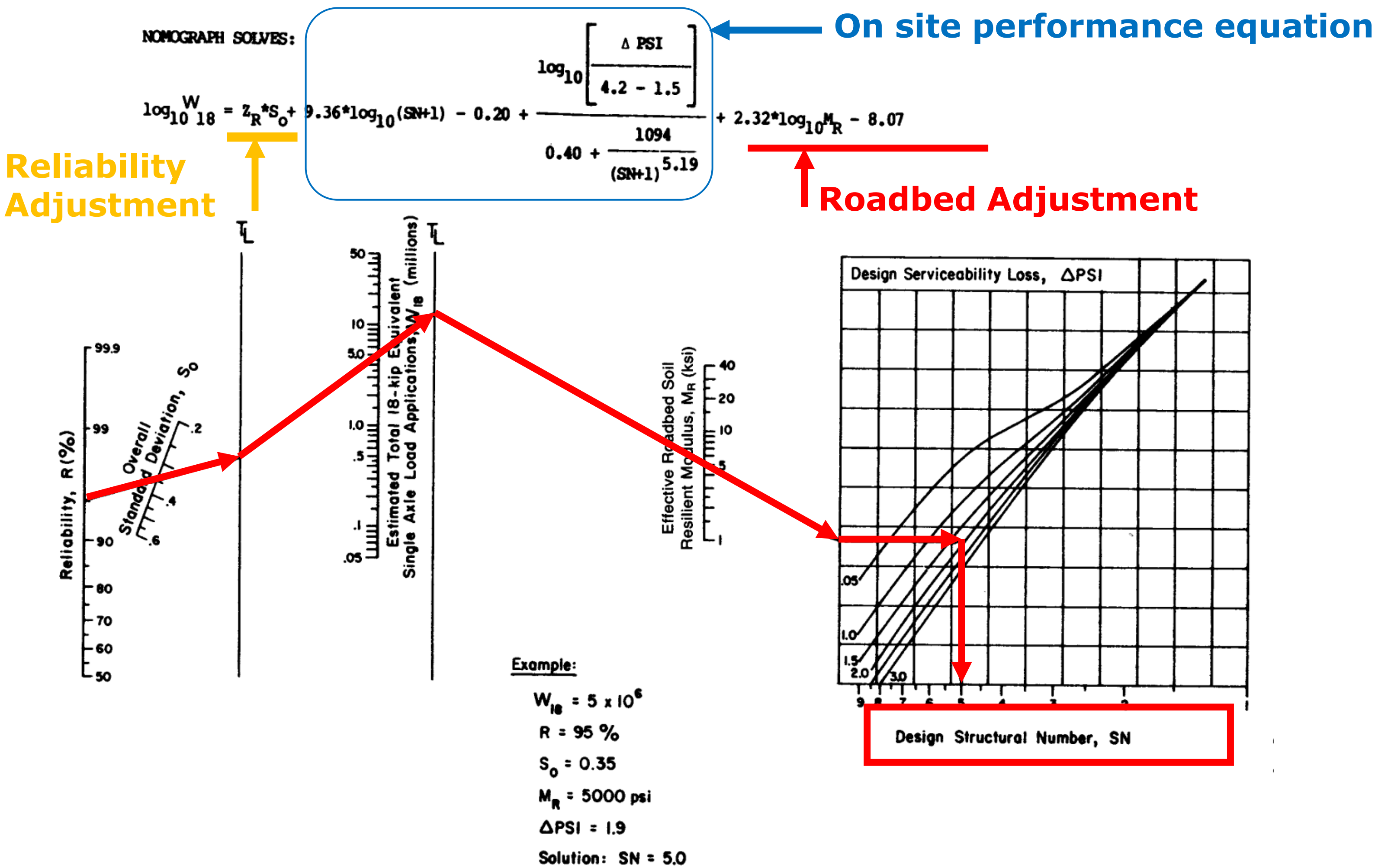
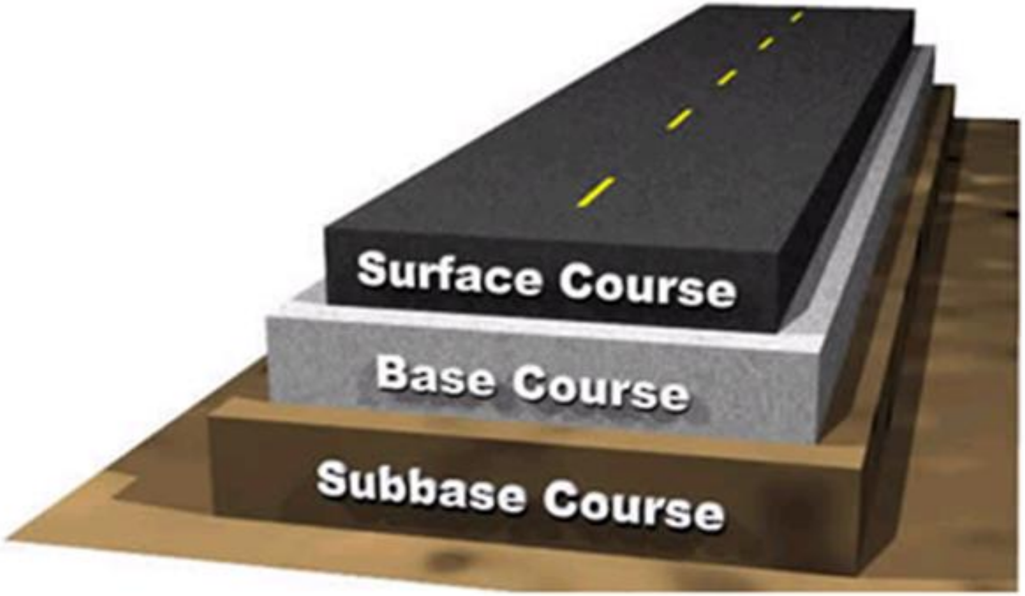


Figure 3.1. Design Chart for Flexible Pavements Based on Using Mean Values for Each Input

PAVED ROAD DESIGN

Converted to a layer depth using coefficients.

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3 + \ldots$$



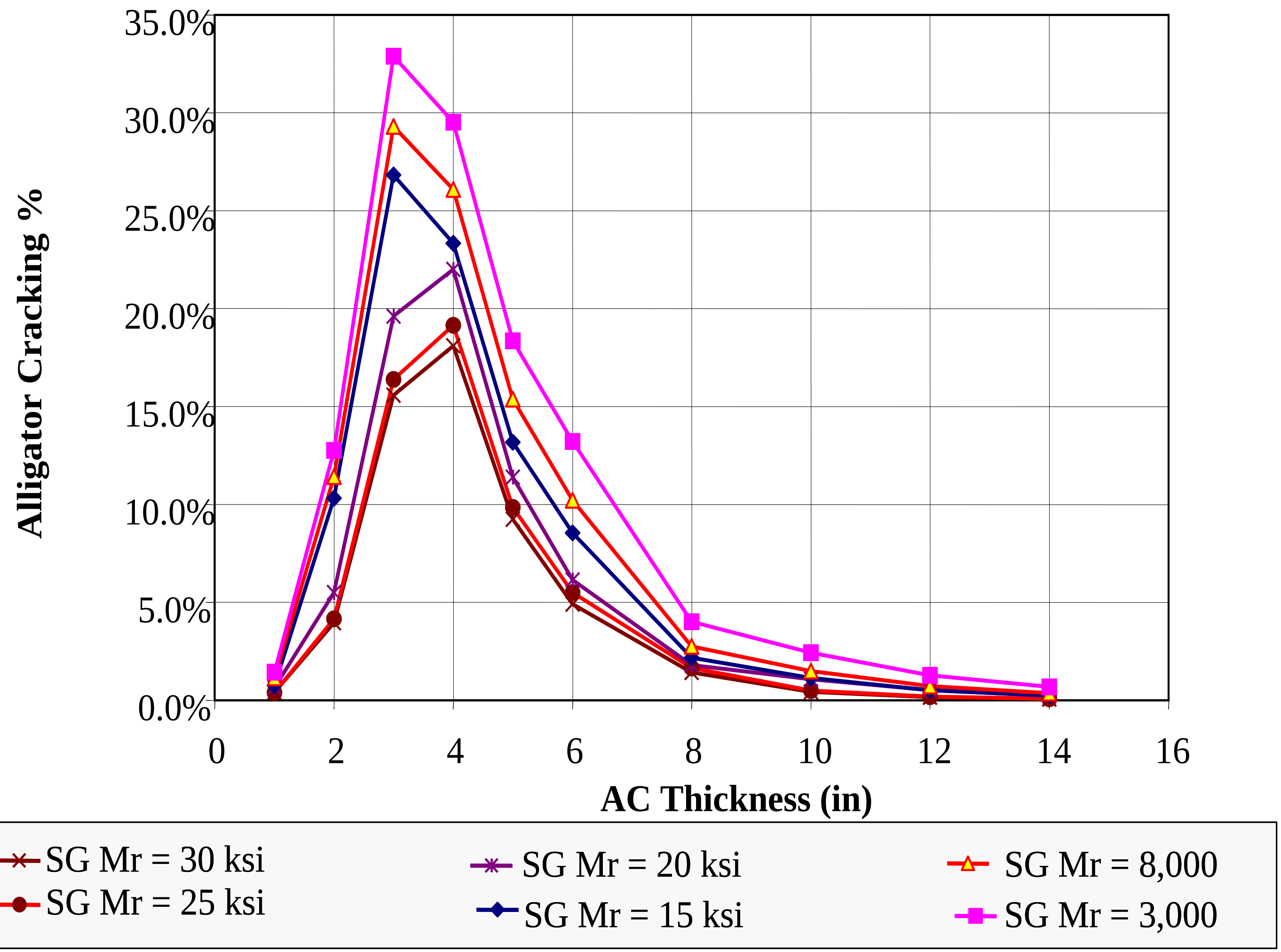
PAVED ROAD DESIGN

For the reinforced case, the TBR is applied to compute an adjusted, or equivalent reinforced, number of 18-kip equivalent single-axle load applications. The equivalent reinforced value is:

$$(W_{18})_R \quad = \quad W_{18} \ x \ TBR$$

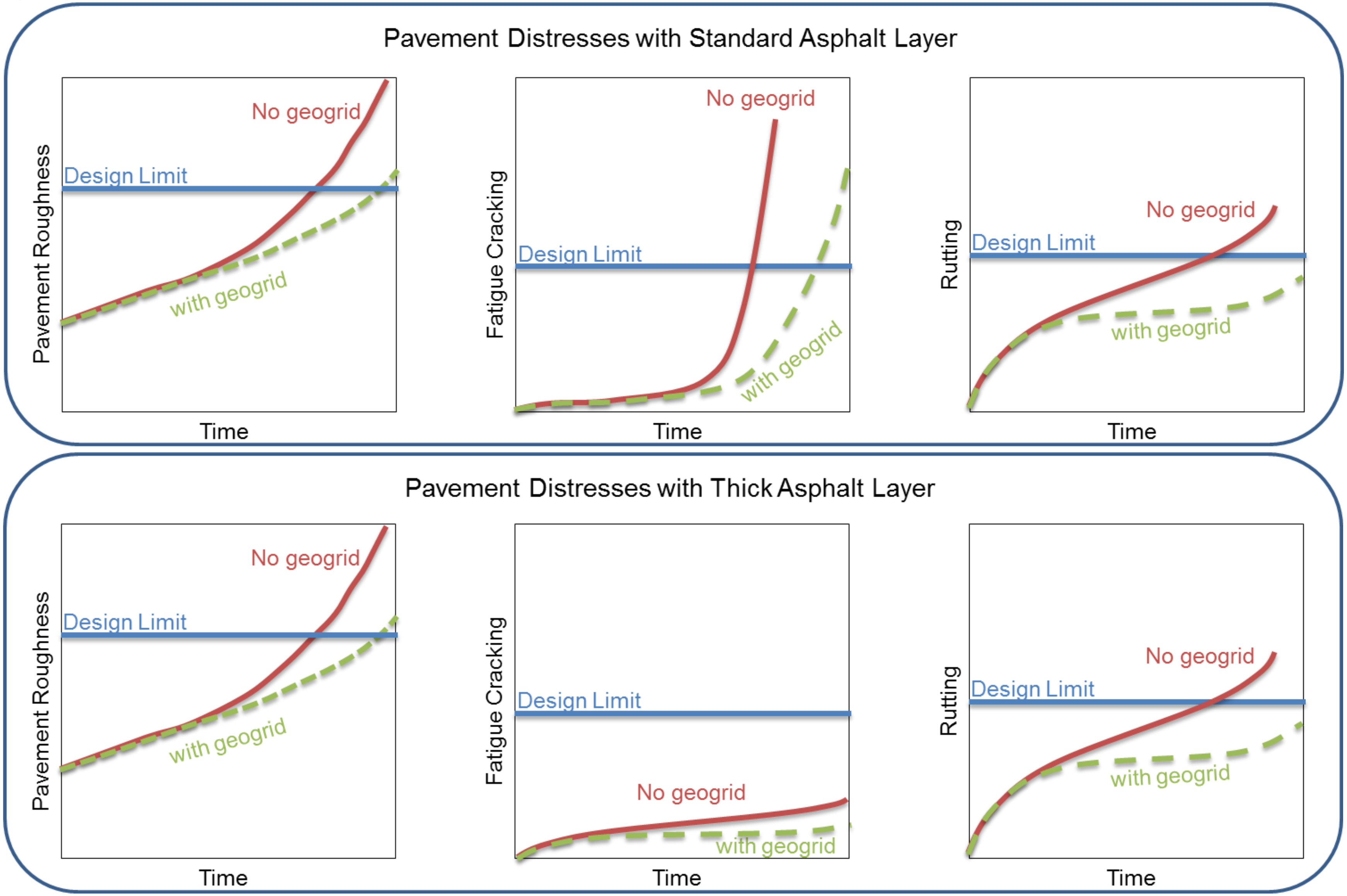
$$\text{TBR} = \frac{GEOGRID\ SECTION\ ESALs}{CONTROL\ SECTION\ ESALs}$$

MEPDG Output*



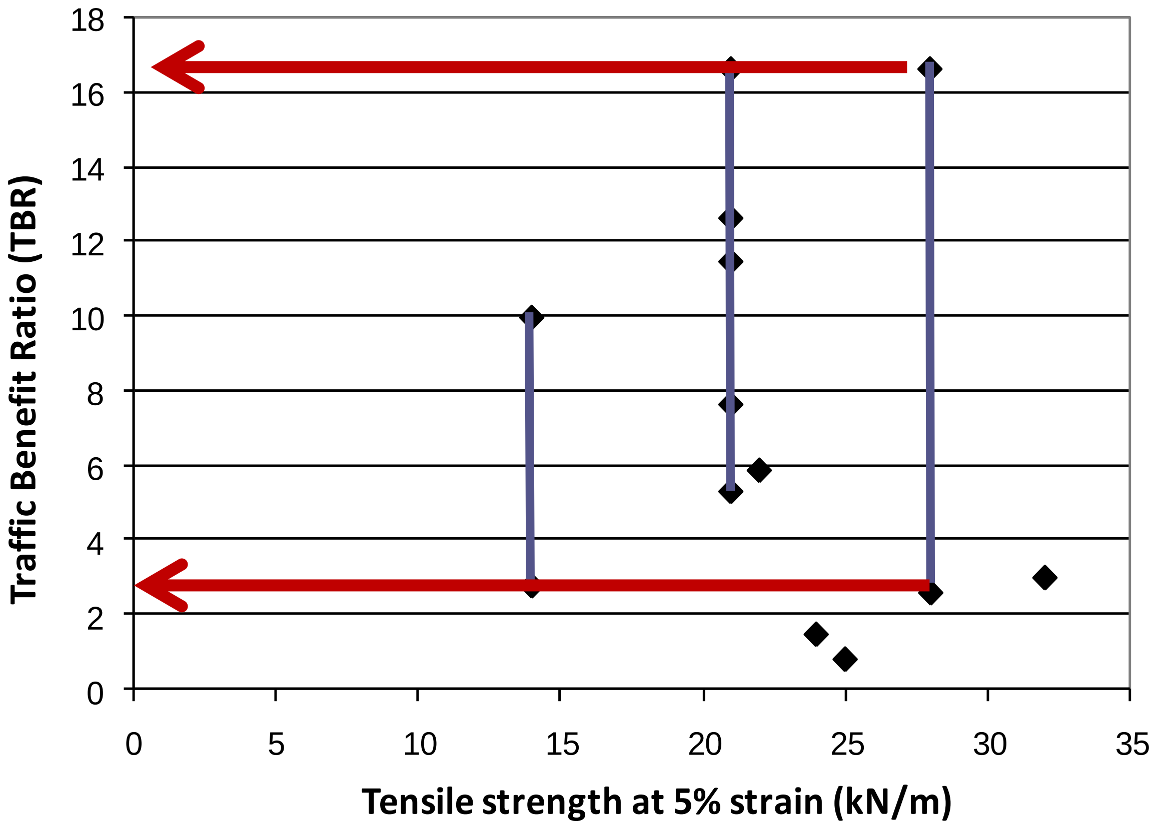
*Courtesy Applied Research Associates, Inc.

Service Life*



*Courtesy Applied Research Associates, Inc.

Performance vs. Index Property

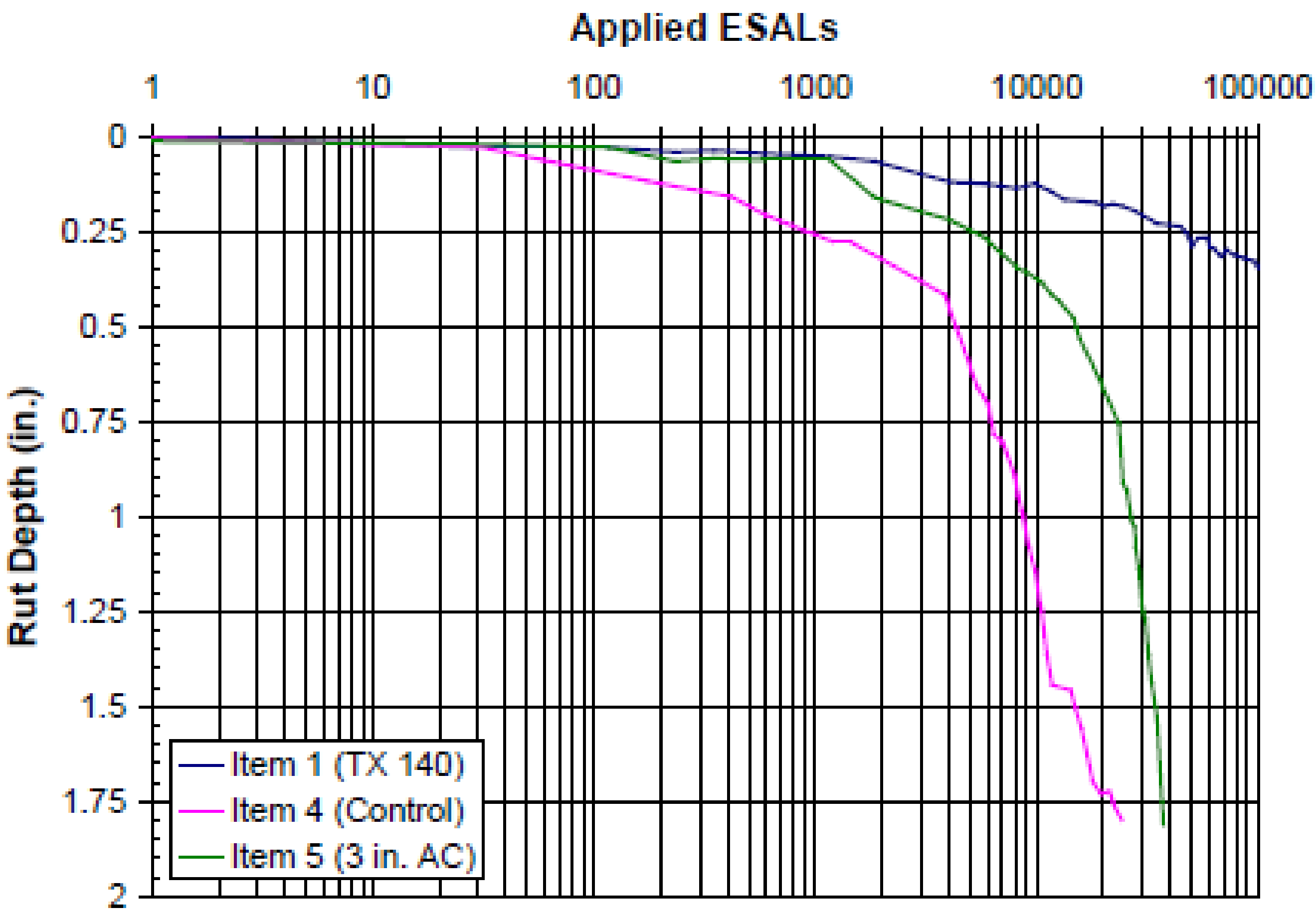


Performance Evaluation

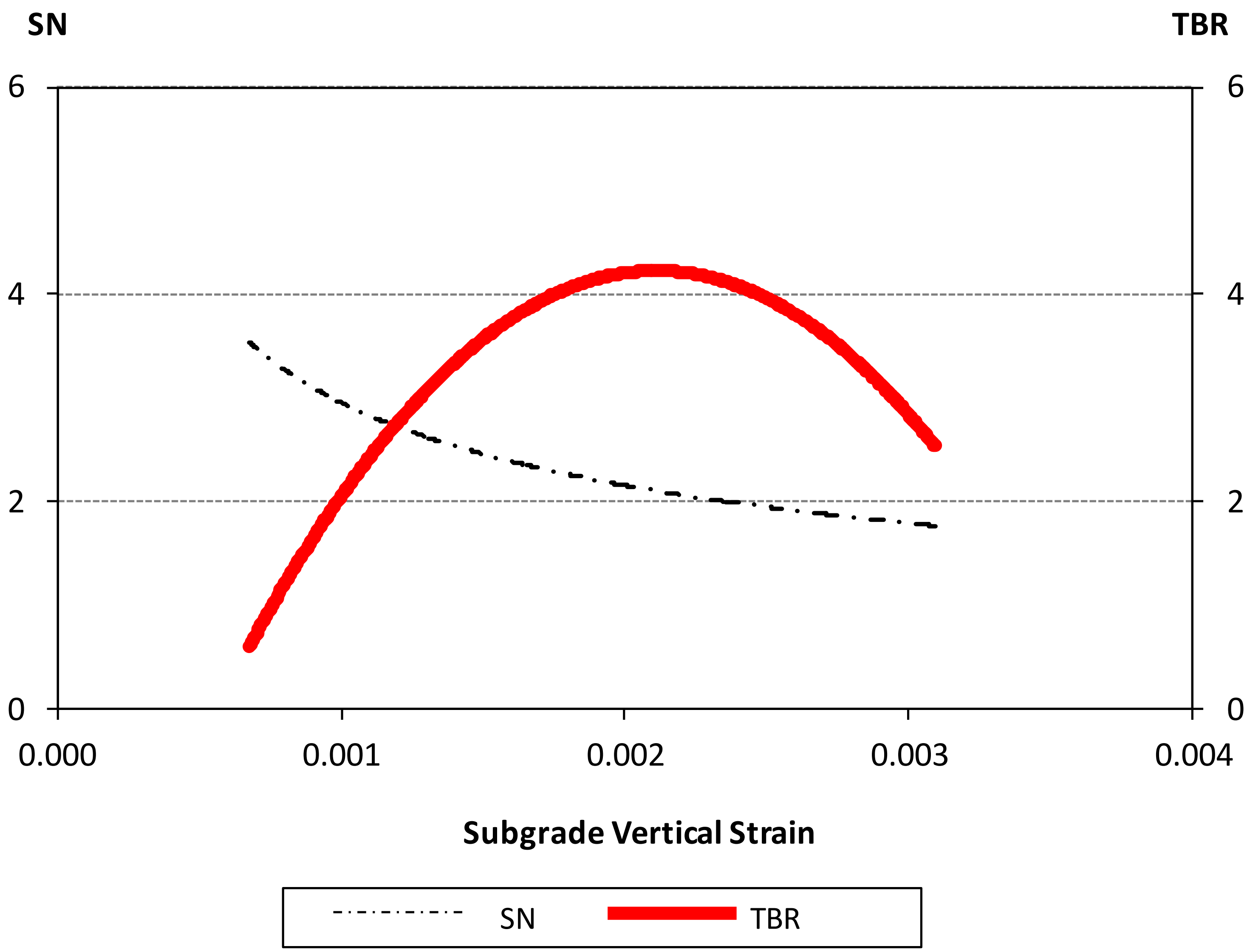
- Full-Scale Testing

Performance Evaluation

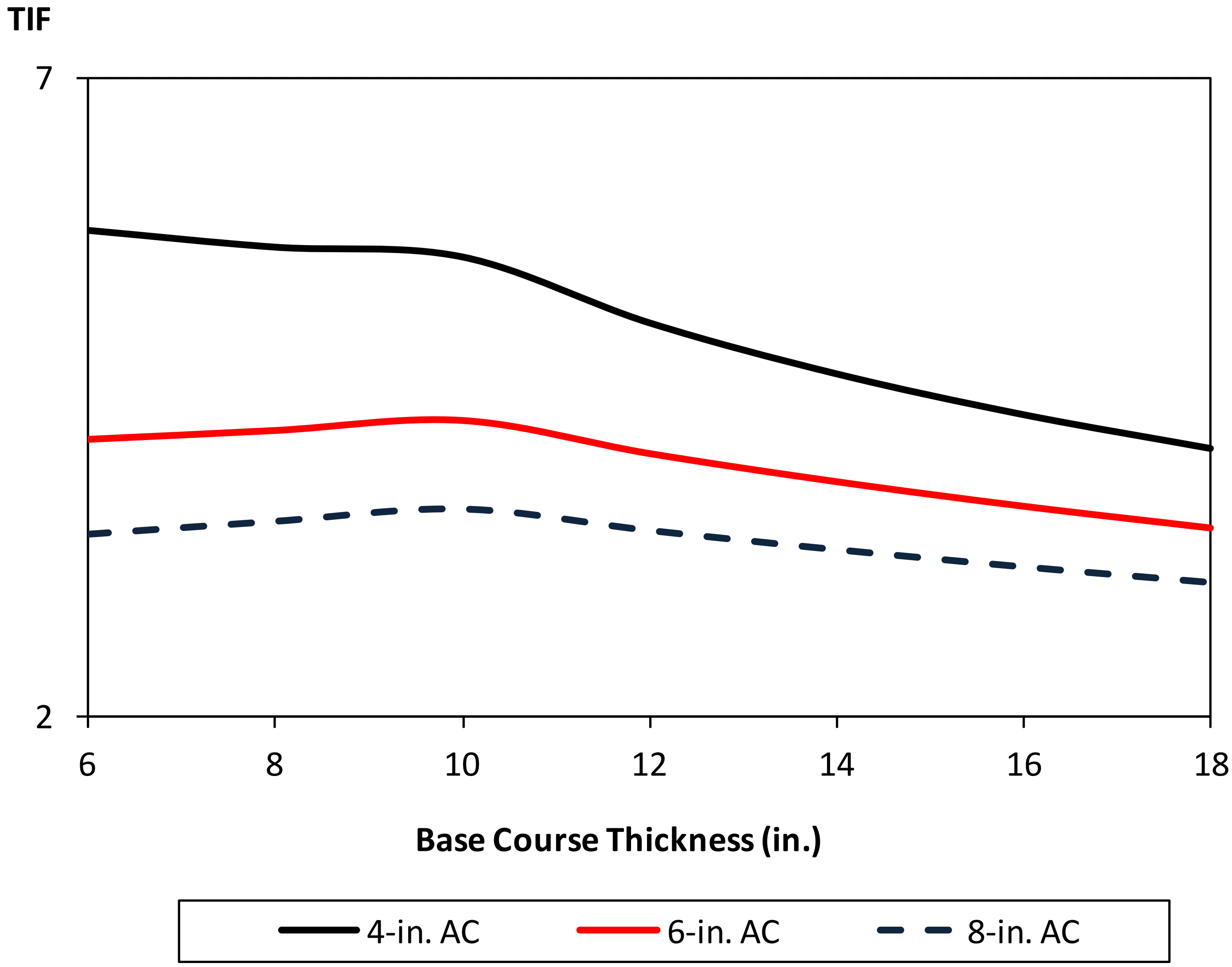
- Full-Scale Testing



Biaxial Geogrid Performance



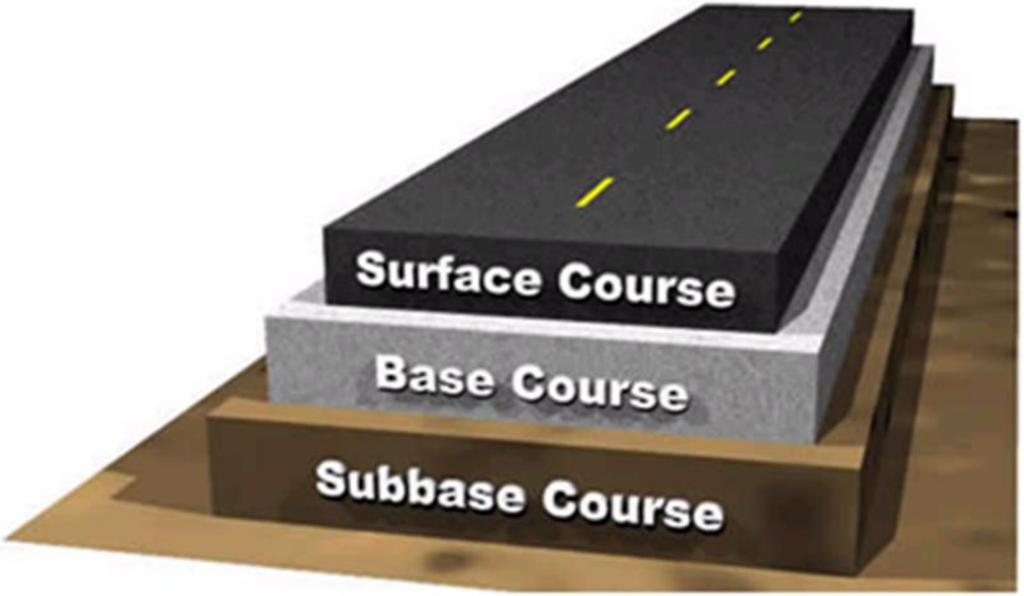
Geogrid Performance



Flexible Pavement Design

- Use of Performance Based Testing

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3 + \ldots$$



Flexible Pavement Design

MSL Aggregate thickness (in.)	Subgrade Resilient Modulus, Mr (psi)		
	5,000	7,500	10,000
6	0.273	0.270	0.266
8	0.247	0.243	0.240
10	0.231	0.228	0.224
12	0.216	0.213	0.210
14	0.205	0.203	0.200
16	0.197	0.195	0.193
18	0.191	0.189	0.187

Summary

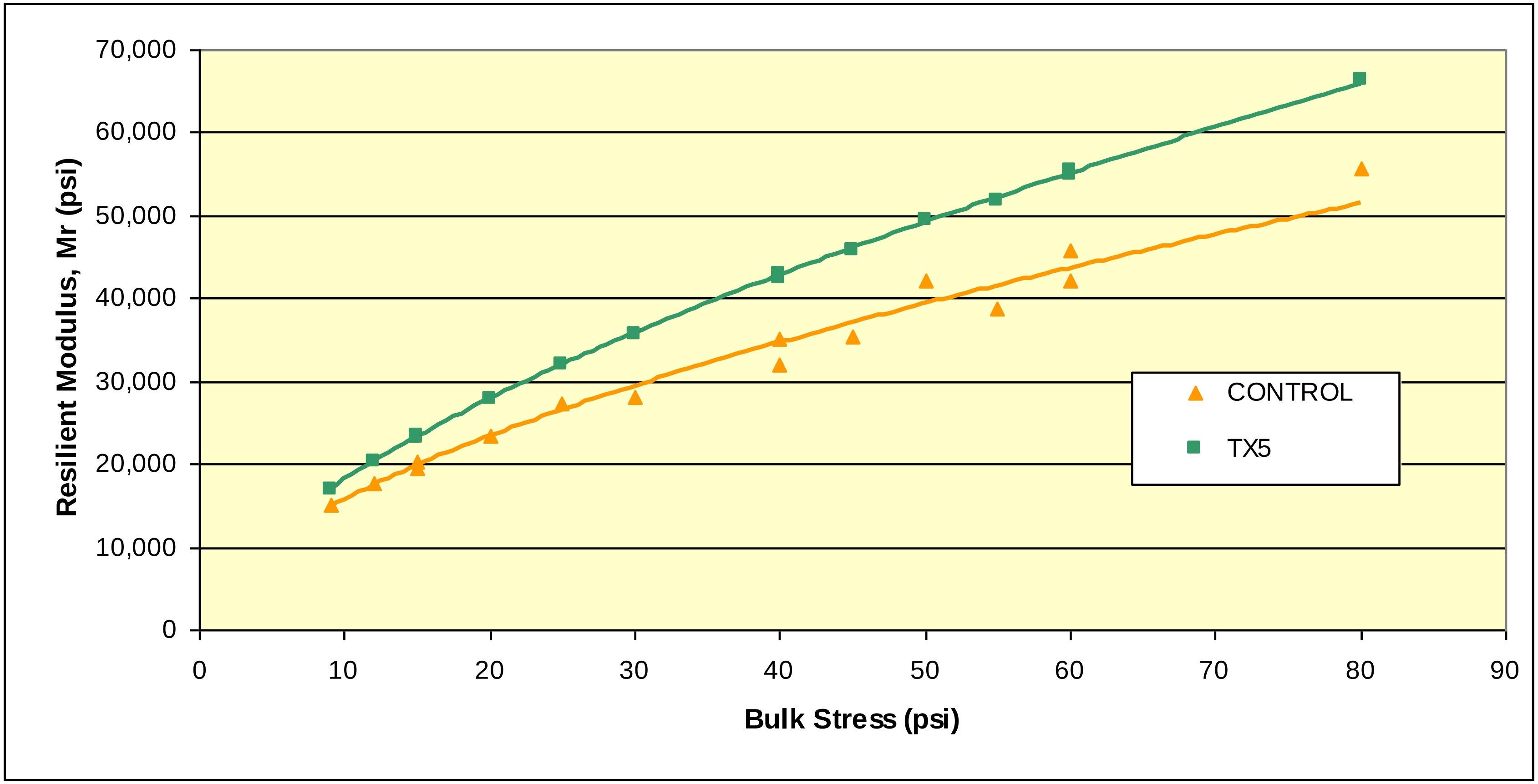
- Optimize Pavement Foundation
  - Design Stabilization Platform
  - This is a Stabilization Layer
- Optimize Pavement
  - Design Base Course Stabilization Layer
  - Full Scale Testing for Support

Future Practice

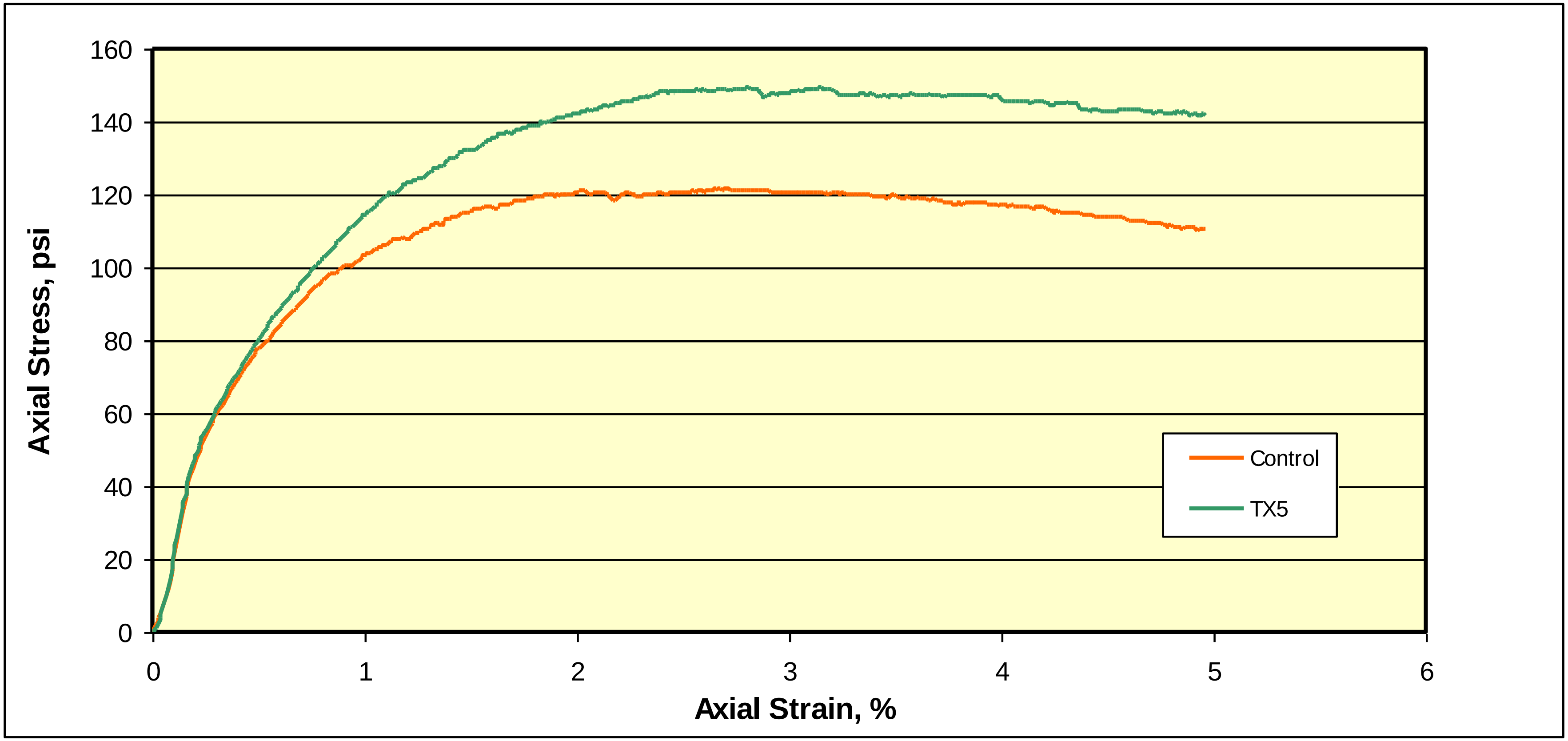
- Laboratory Performance Testing
  - T307 Resilient Modulus
- Construction QC/QA
  - Intelligent Compaction
  - Dynamic/Static Plate Load Testing

T307 Triaxial Cell

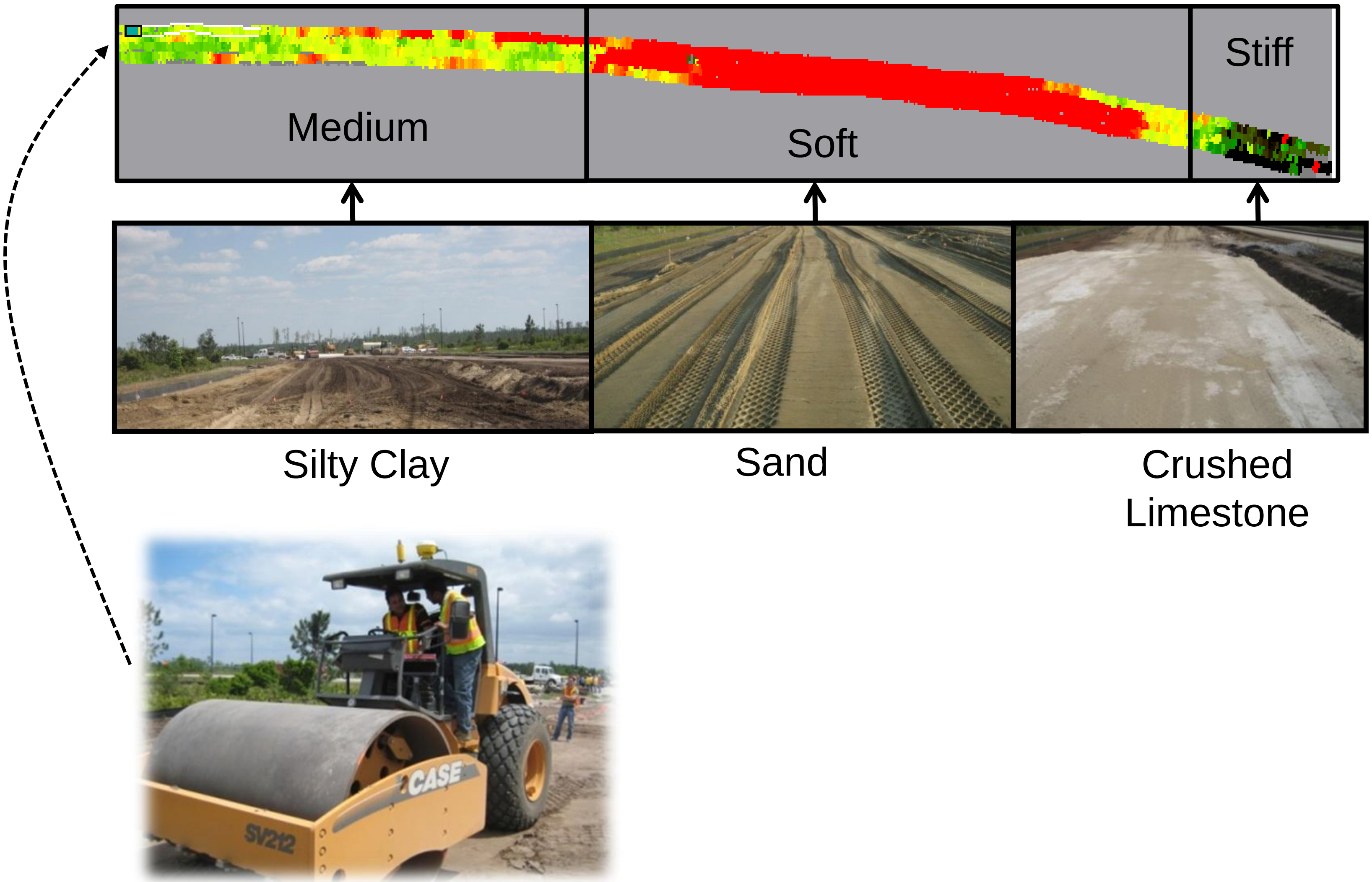
T307 Resilient Modulus



T307 Quick Shear

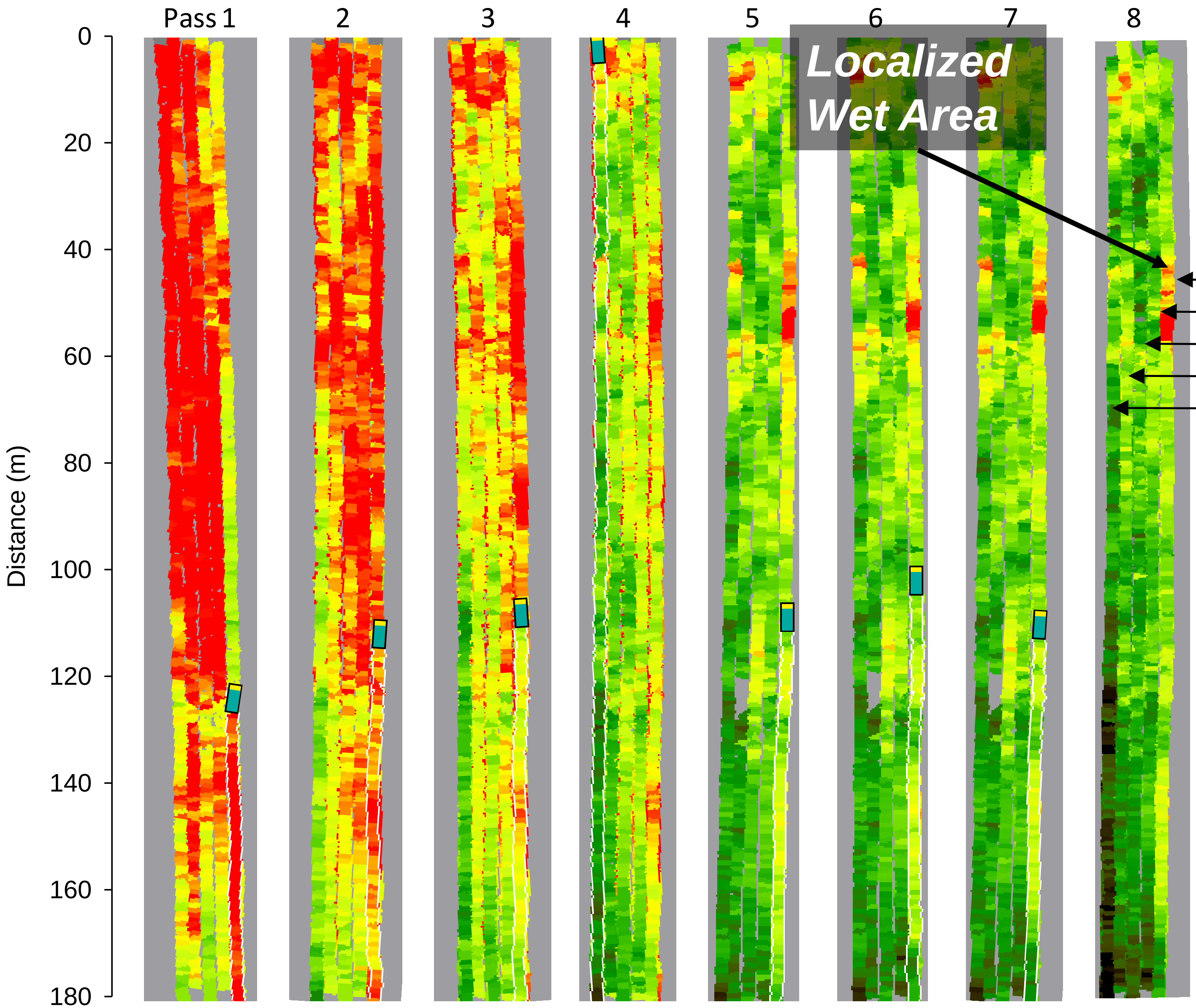


k_s indicates changes in support conditions due to changes in pavement foundation materials.

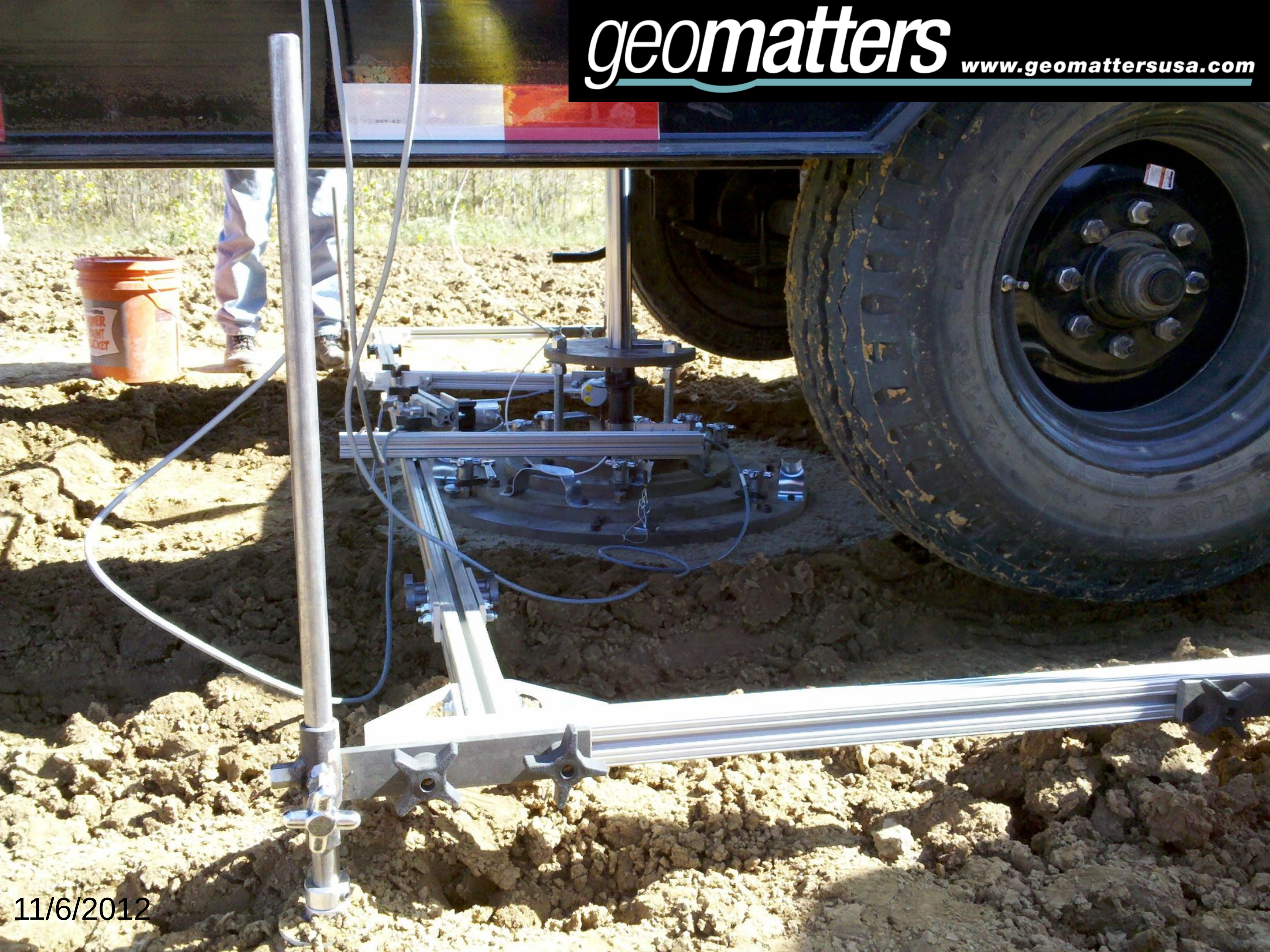


Courtesy Iowa State University

k_s shows compaction progress and soft area.



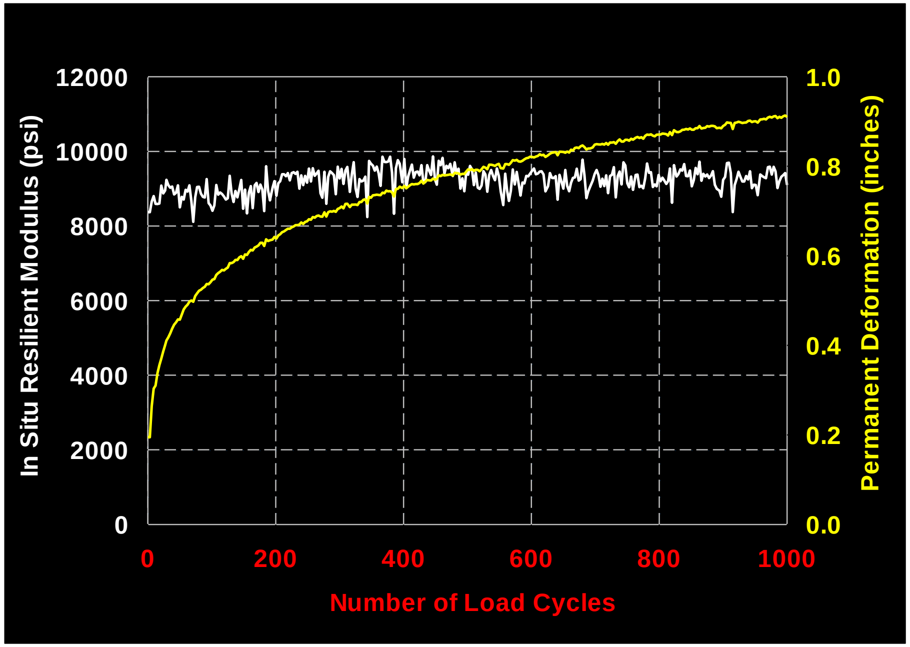
Cohesive Subgrade


geomatters
www.geomattersusa.com
11/6/2012

Automated in situ measurement technologies are setting new standards for quality assessment.

Automated testing to assess:

- Modulus of subgrade reaction
- In situ resilient modulus
- Confining stress dependent cyclic modulus



This equipment is US Patent Pending disclosed in U.S. Provisional Patent Application No. 61/621,059, filed April 11, 2012. A South American application will claim priority back to the pending U.S. provisional patent application.

Questions?

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