Introducing a Geogrid Gain Factor for Flexible Pavement Design

Minnesota Pavement Conference
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David Potyondy and Lee Petersen, Itasca

Your Destination...Our Priority

Acknowledgements

- Local Agencies
- MnDOT Districts and Offices
- Private Sector Engineers
- Product Manufacturers
- Universities

Why Geogrid

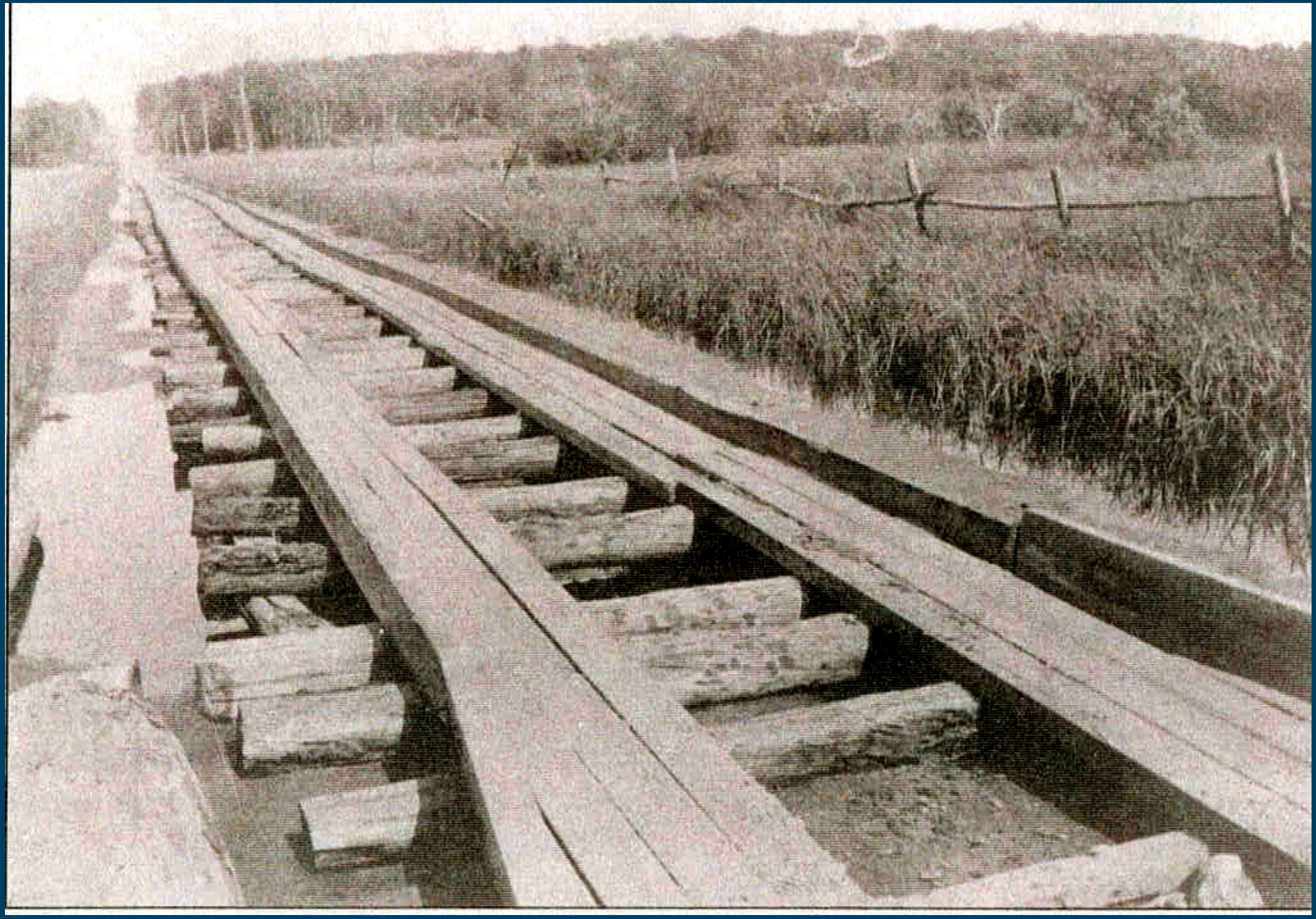
Why Geogrid

"Spread the Load" – Graig Gilbertson

Why use Geogrids

- Reduce cracking – non thermal cracks such as longitudinal
- Gain strength – especially in the springtime and over weak non uniform grades
- Reduce grade raise
- Minimize Construction Time
- Tying widened sections to mainlines
- Long detours with limited options under traffic
- Insurance – relatively cheap insurance for the unknowns
- Cost – Minimal vs. Regrading

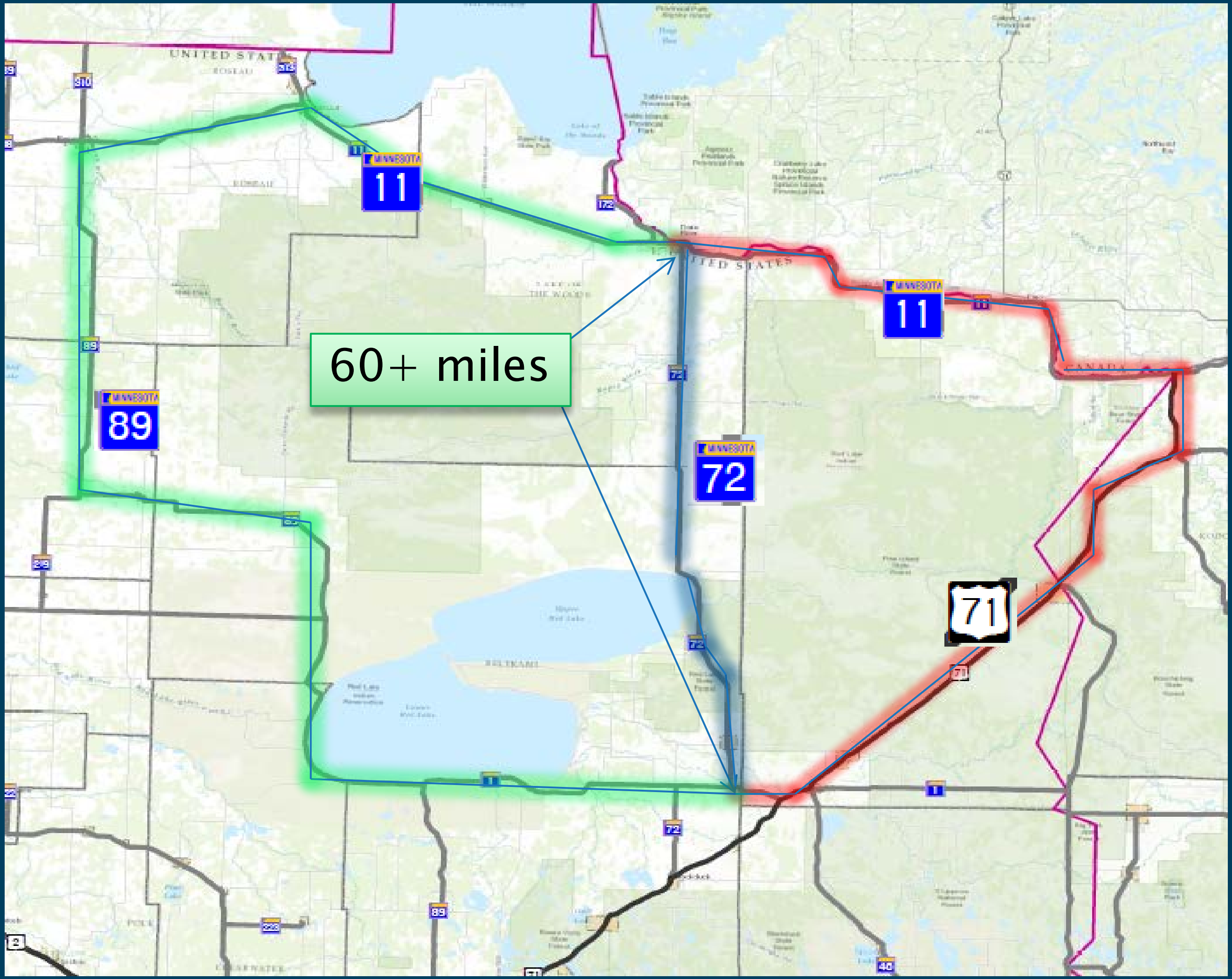
Early Form of Grid



Early Forms of Geogrid

Corduroy

Detour Options

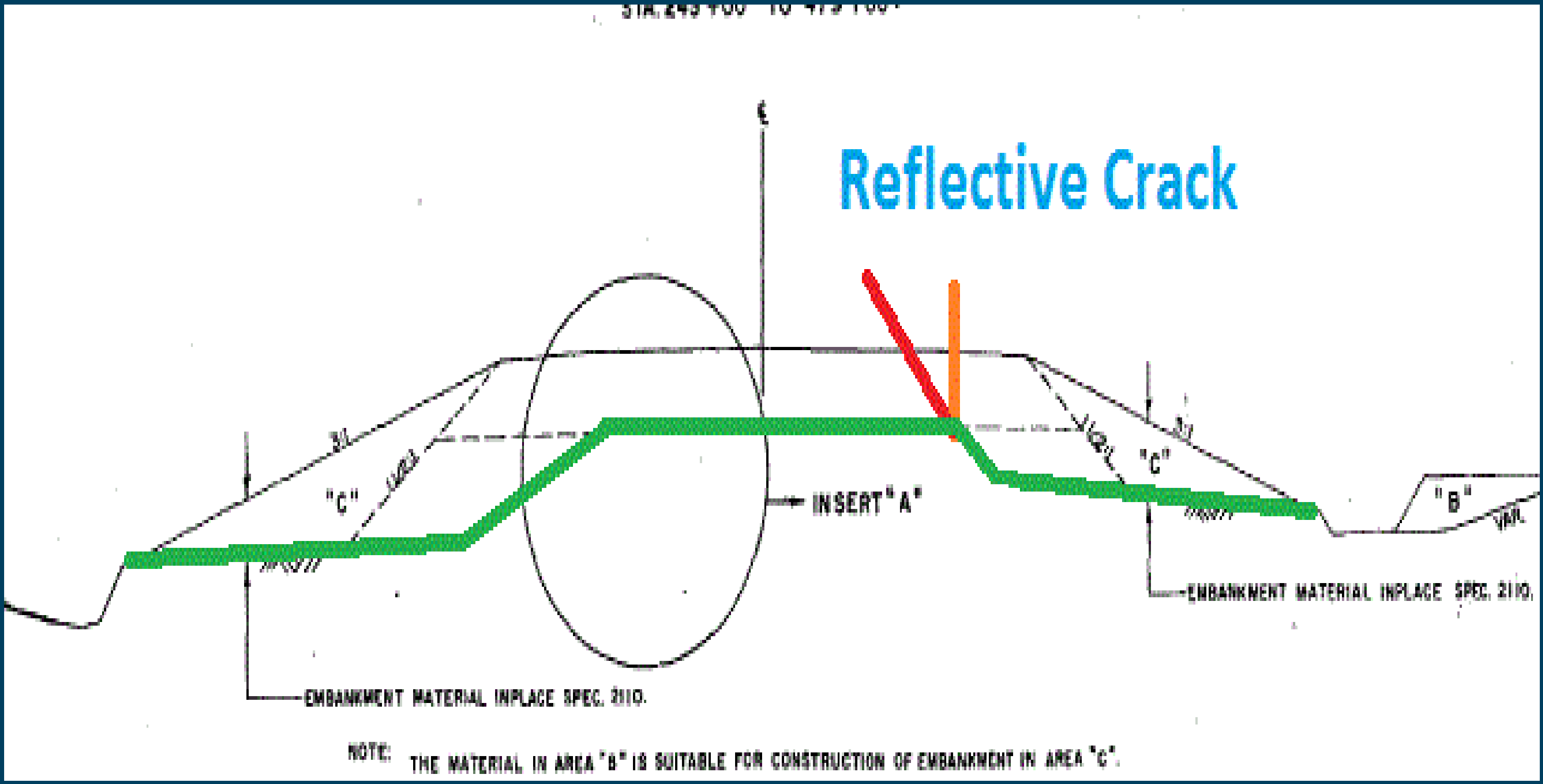


History – D2 Bemidji

- 1997 – Test sections on TH 72 using Type 5 and 6 fabrics, geocell, and geogrid. No clear cut winner
- 1997 – Test section on TH 11 with geogrid.

TH 72 1918 Grading

TH 72 Typicals



TH 72

TH 72 – 1997 Test Sections

Type V Geotextile

Type VI Geotextile

Geocell

Biaxial Geogrid

2000 – Polk and Hubbard

TH 200 – 2003

TH 72

1994 – 2005 11 years

2005– 2015 10 years





W:094°33' 13.08"
N:048°13' 08.37"

TH 11 – 2010

1984 –2009 25 years

2010 – 2015 5 years

TH 72 – 2011

1997 – 14 Years

2015 – 4 Years

TH 310

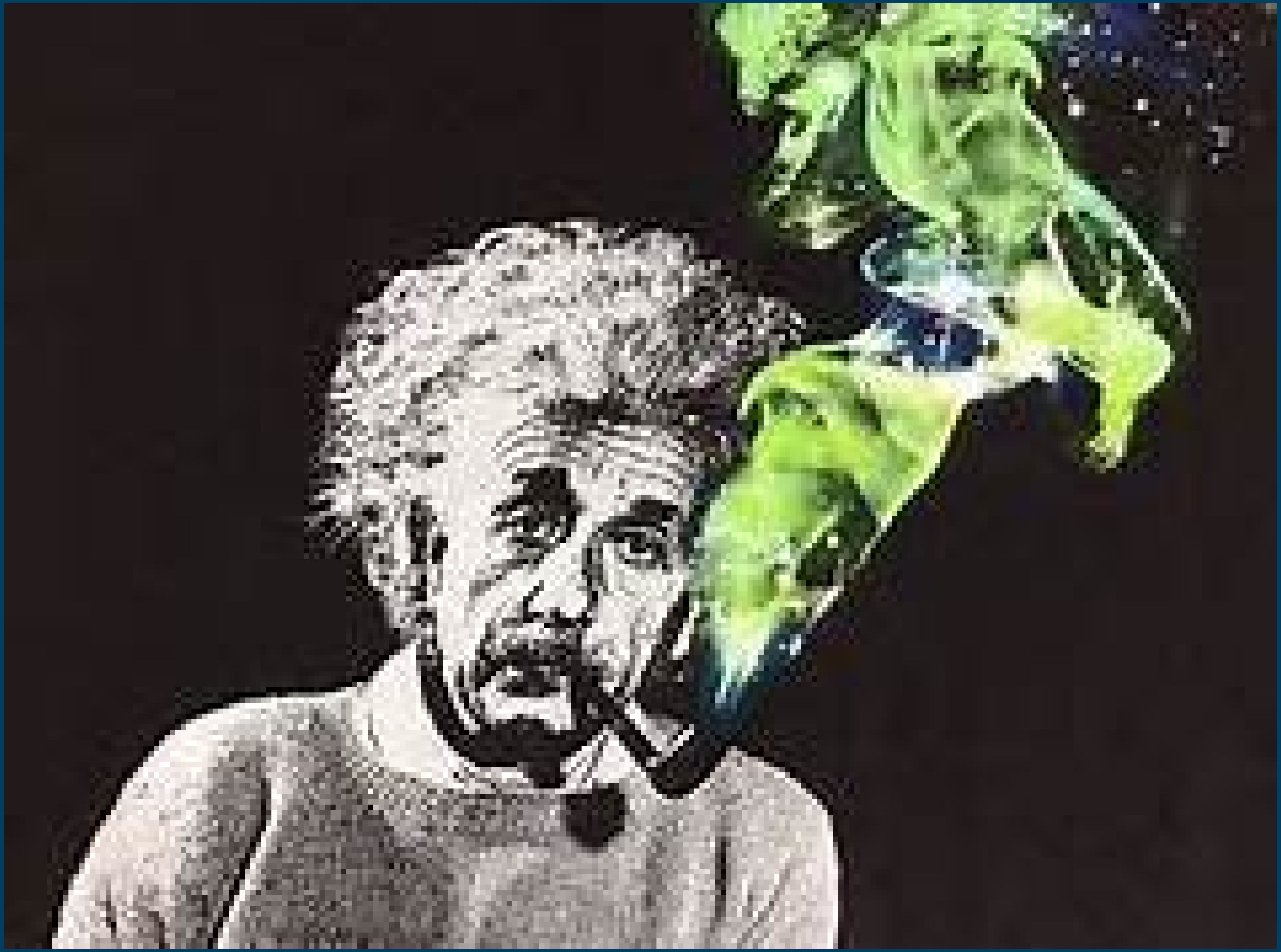
2012

2015

Design/Research

- Gradual improvements – for the selection and placement
  - When to use biaxial vs. uniaxial
  - Placement – direction/overlap
- There still has not been a tool or method to include or give credit for the geogrid in MnDOT Design method.
- How do we quantify it?
  - State Aid started giving geogrid a GE of 2 inches.
- Is the benefit consistent throughout the year
  - Actually more in the spring or larger loads when you need it

Now for the Technical Stuff



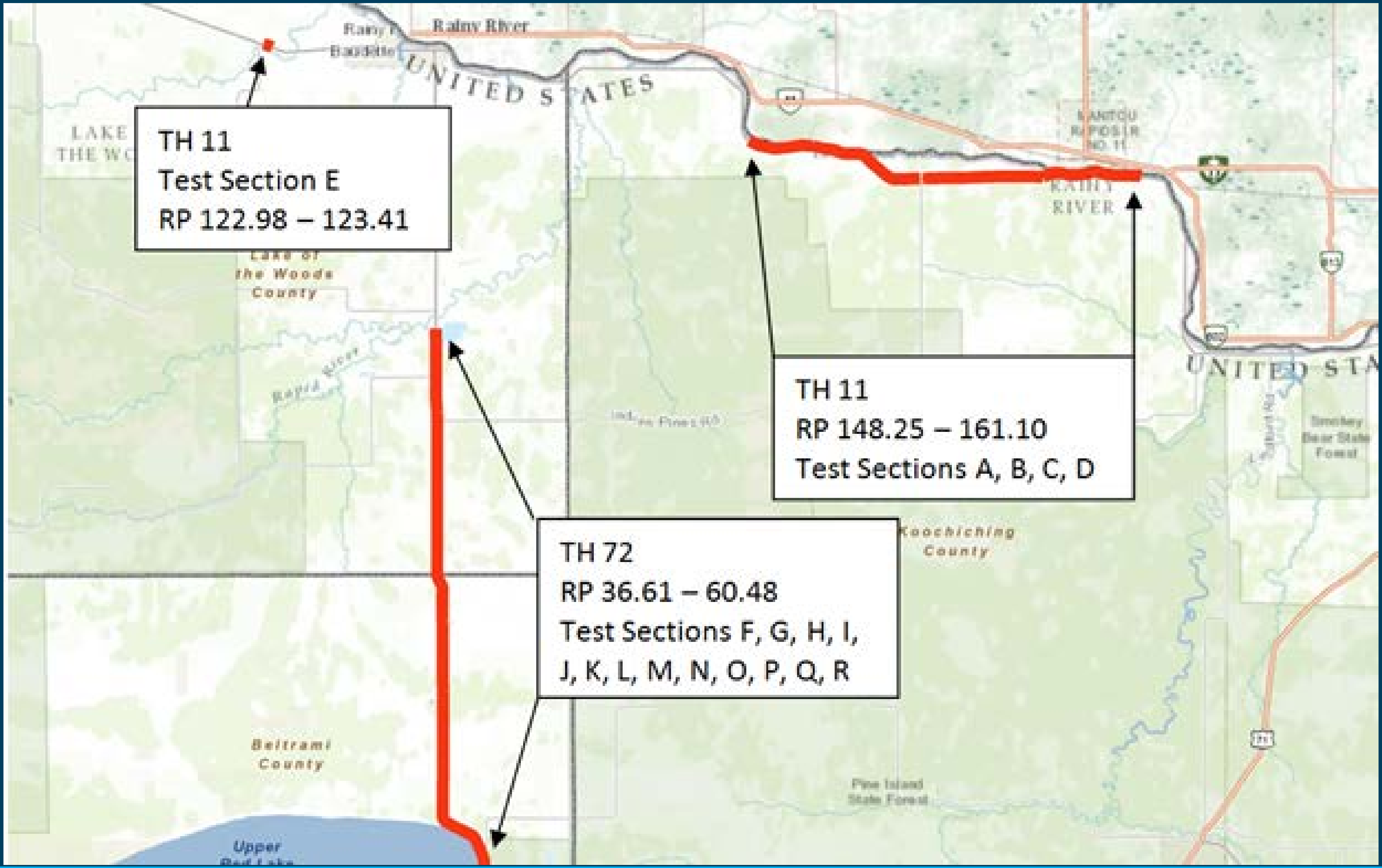
Current Situation

- Geogrids are used in base layers to enhance flexible pavement performance.
- For State Aid highways, multiaxial geogrid shall have a granular equivalent value of 2 inches.
- MnPAVE is MnDOT's pavement design method for estimating pavement performance and quantifying geogrid benefit.

Project Objective

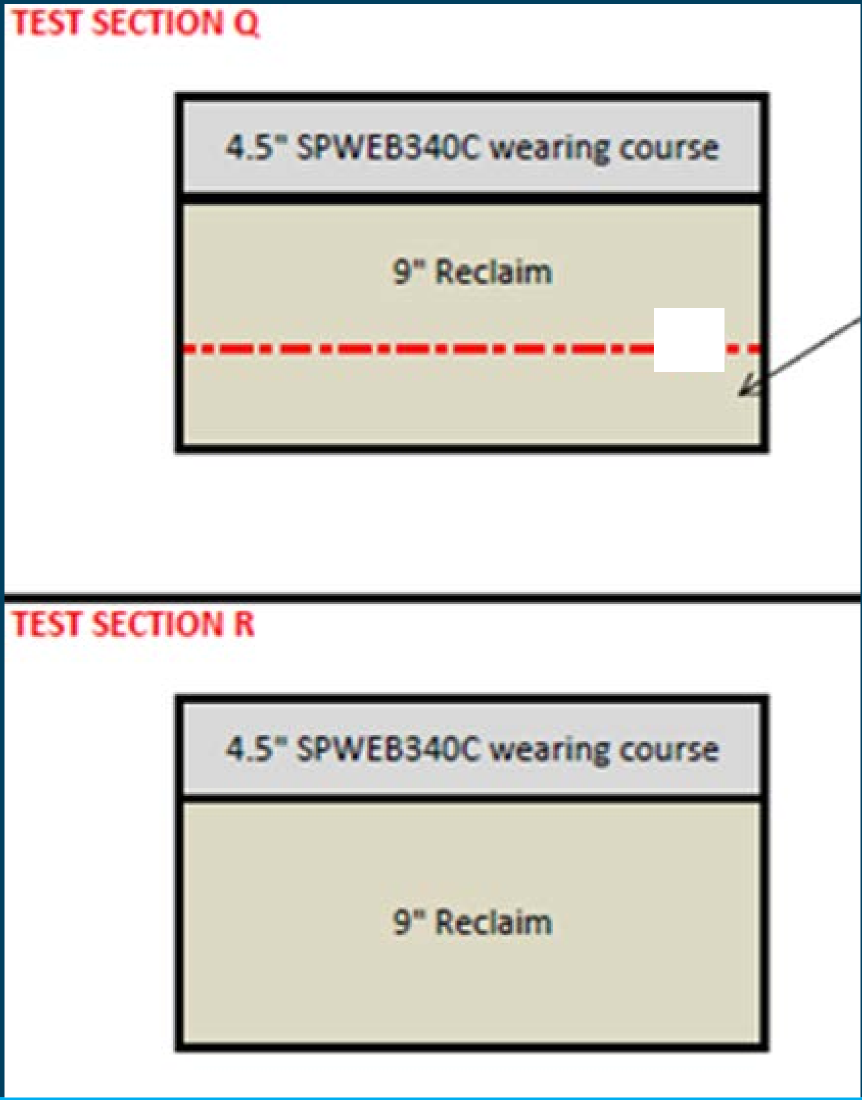
- Design procedures and construction specifications are modified to better support geogrid utilization so that we build financially effective roadways.

Geogrid Project Locations



Geogrid in Aggregate Base Layer

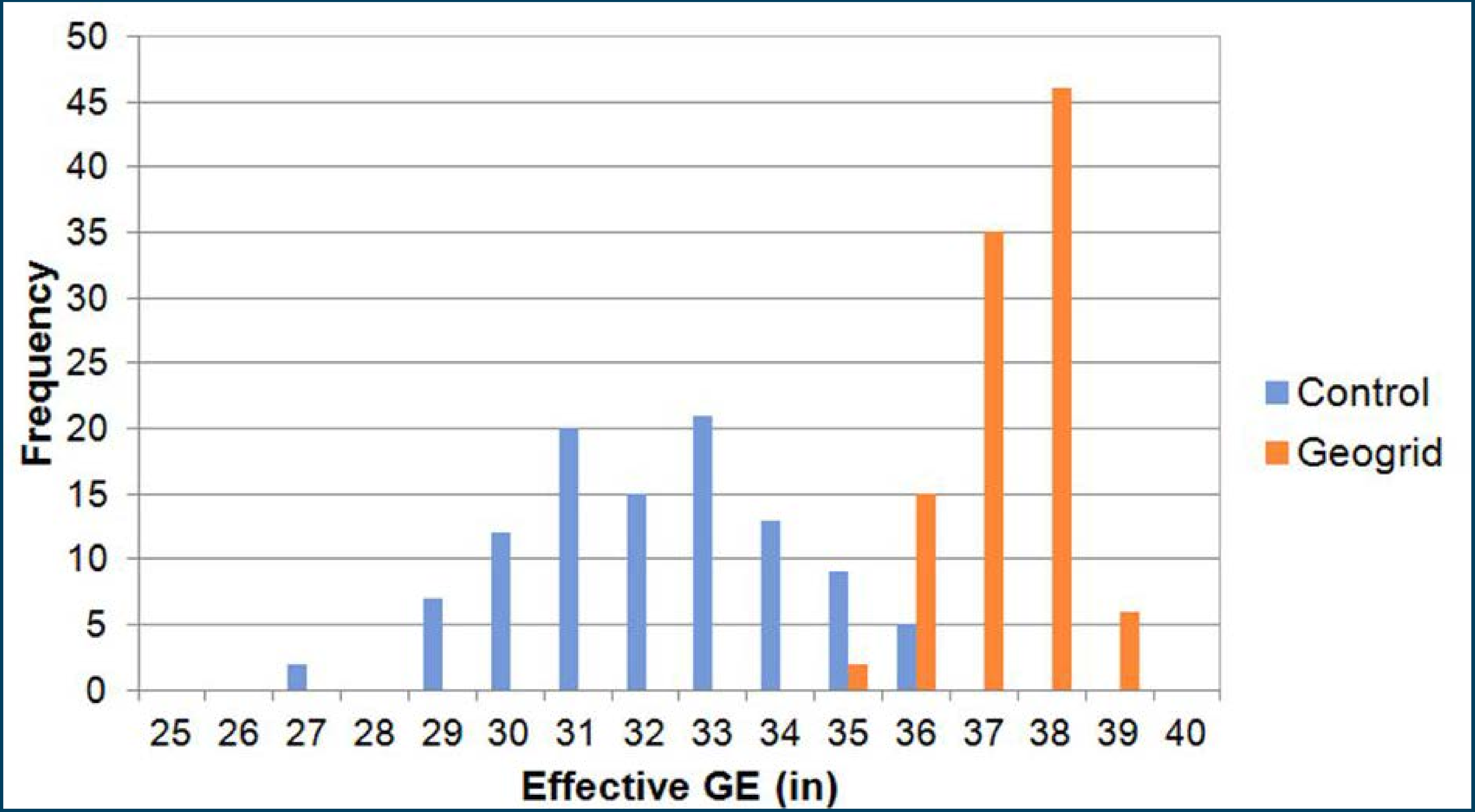
- Ideally geogrid would be the only difference between test sections.
- Reality is that other variables include soil, water, and temperature.



Falling Weight Deflectometer

- Simulates traffic loads
- Measures surface deflections
- Fast and non-destructive

Preliminary Analyses FWD



Minnesota Department of Transportation
Office of Materials & Road Research
1400 Gervais Avenue, MS 645
Maplewood, MN 55109

Memo

TO: PCMG, CMG, MnDOT Districts, Materials Engineers, Soils Engineers, State Aid

FROM: Glenn M. Engstrom, Director
Office of Materials & Road Research

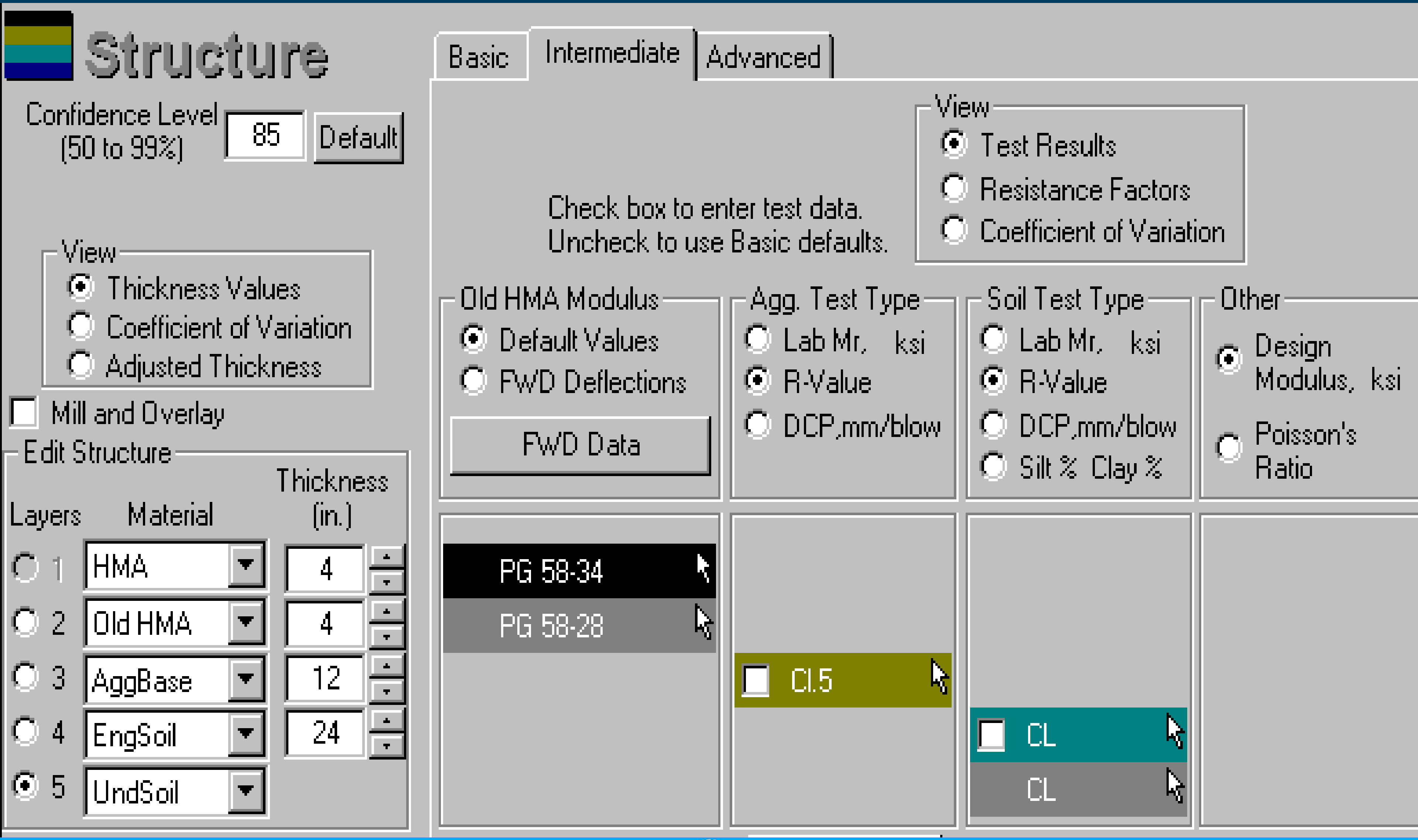
DATE: October 31, 2014

SUBJECT: Pavement Design Manual Publication

I am pleased to announce the publication of the MnDOT Pavement Design Manual.

This publication represents a significant effort to update pavement design procedures and codify existing documents into a single point of reference. As of November 1, 2014, all MnDOT pavement designs shall follow the pavement design, pavement-type selection, LCCA, and alternate bidding as laid out in the Pavement Design Manual. To view the manual, please follow http://www.dot.state.mn.us/materials/pvmtdesign/newmanual.html

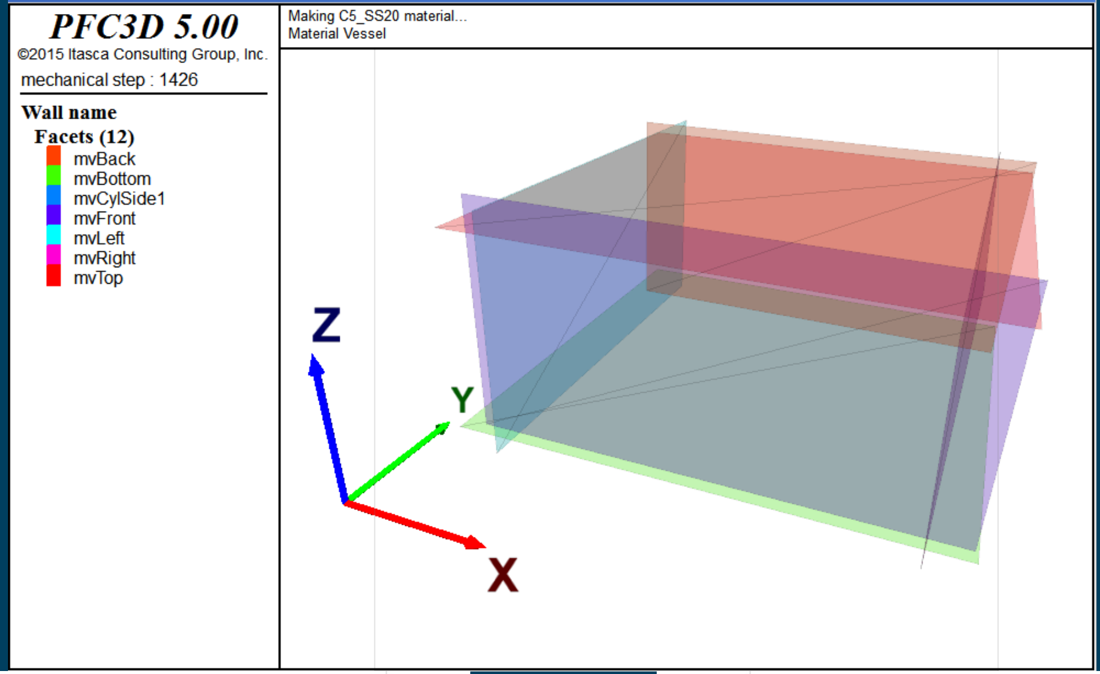
Need Mechanistic Design Inputs

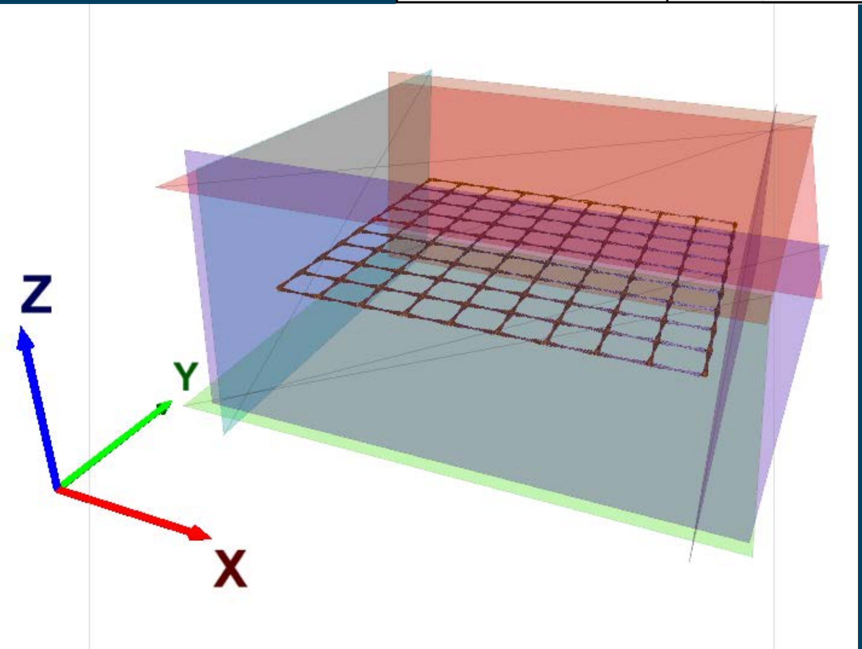


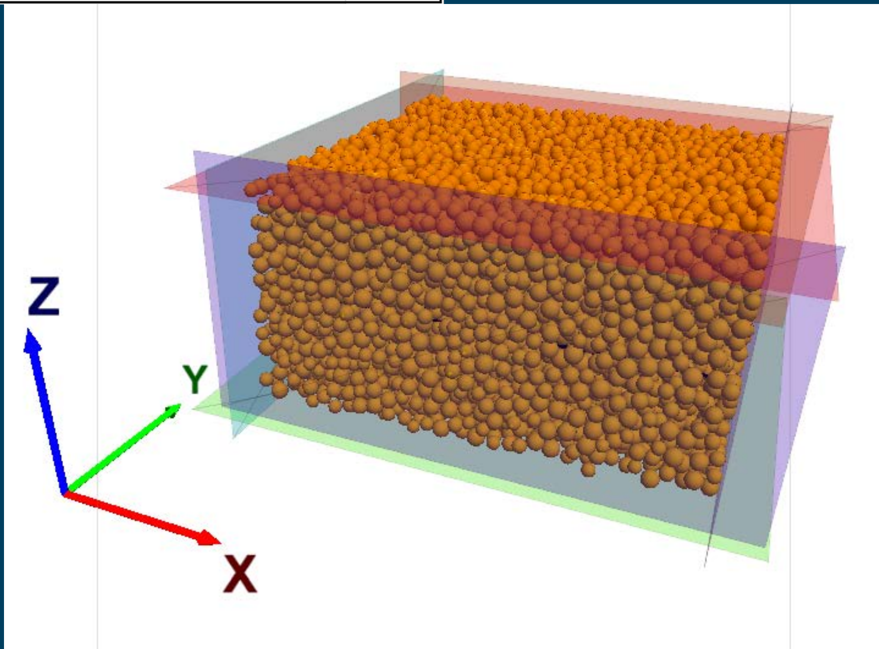
Lab Resilient Modulus

Numerical Modeling of

Lab Resilient Modulus


PFC3D 5.00
©2015 Itasca Consulting Group, Inc.
mechanical step : 1426
Wall name
Facets (12)
mvBack
mvBottom
mvCylSide1
mvFront
mvLeft
mvRight
mvTop
Making C5_SS20 material...
Material Vessel
Z
Y
X


Z
Y
X


Z
Y
X

Parameters Studied

Aggregate gradation

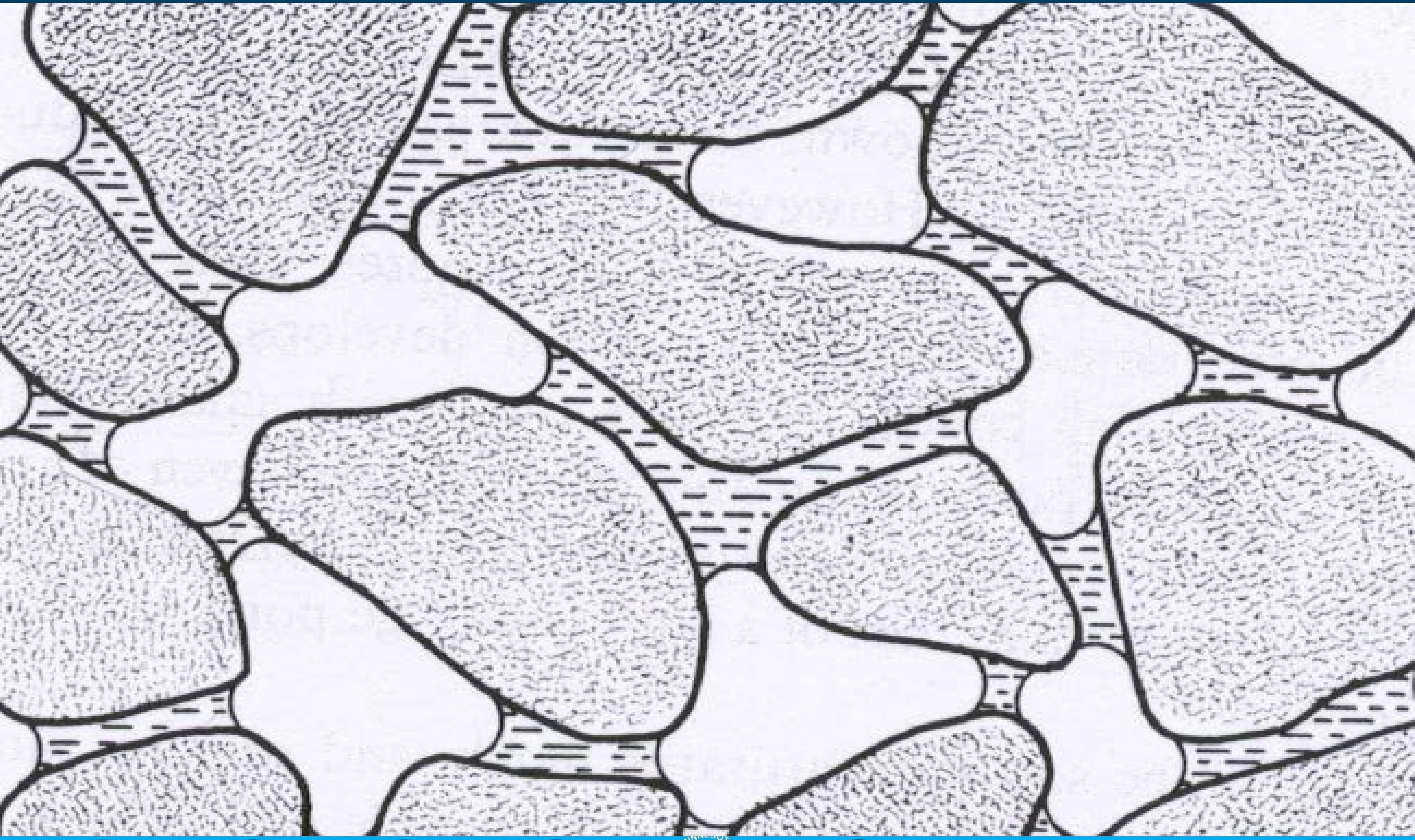
Friction between particles (roughness)

Confining stress

Moisture content (moisture tension)

Geogrid properties

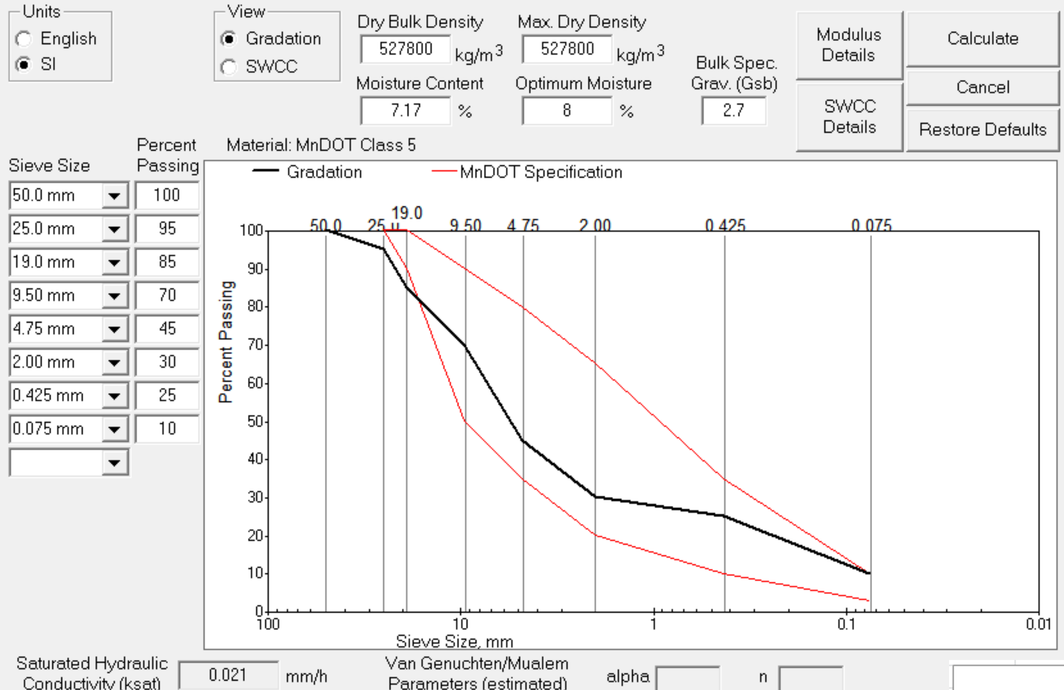
Fundamentals of Soil Physics, Hillel

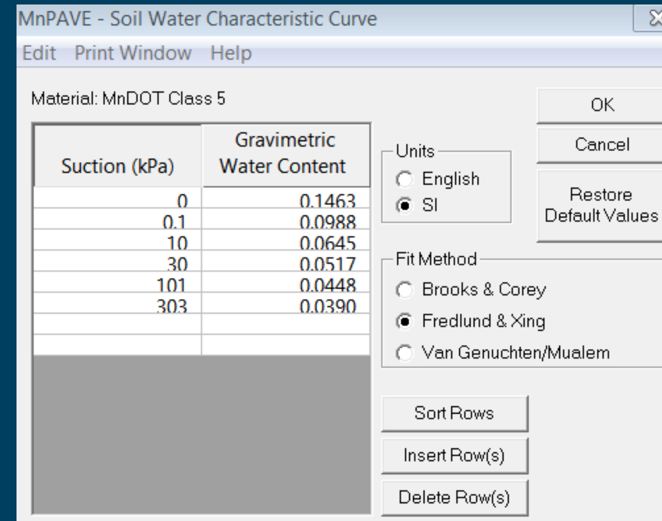


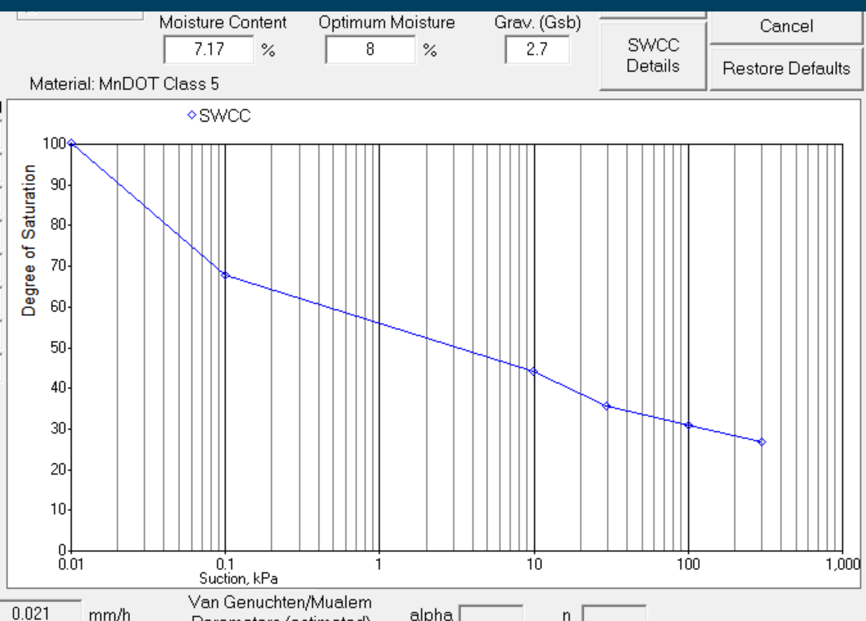
Unsaturated Soil Mechanics

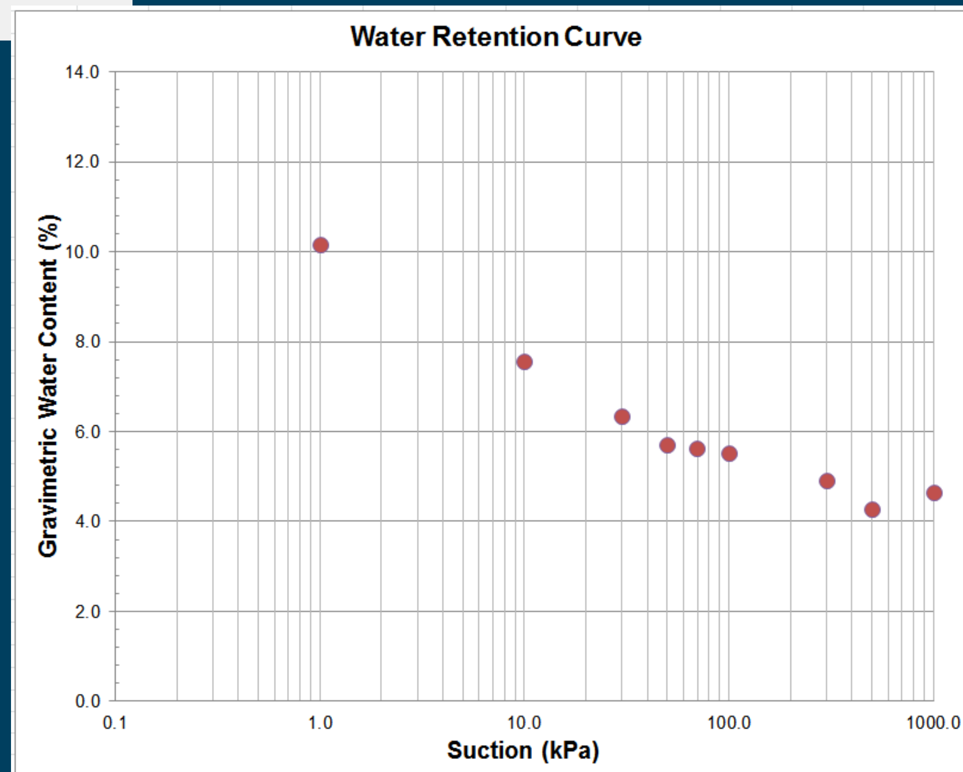
- Modulus greatly affected by moisture tension between particles.

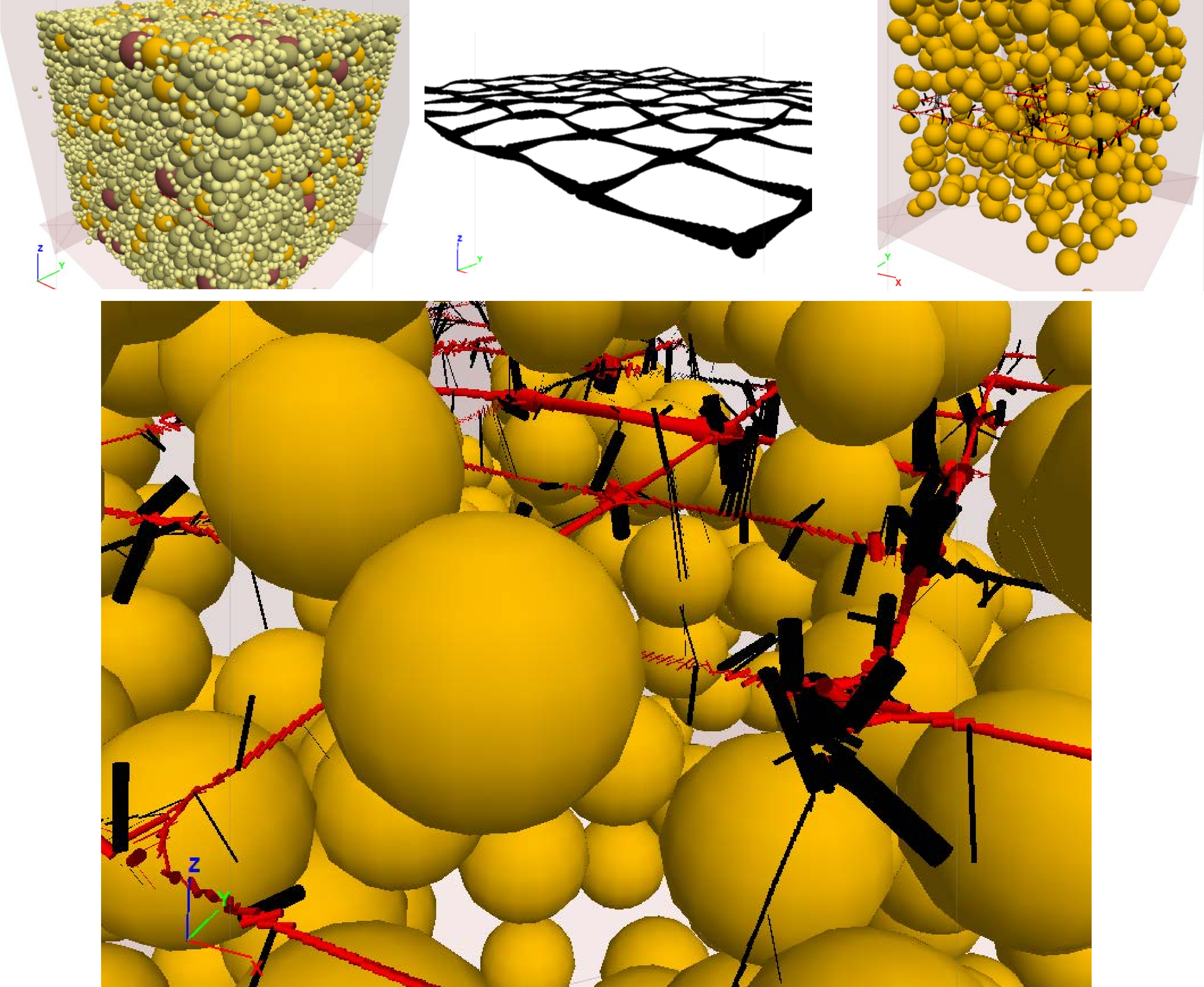
- Moisture tension between particles depends on:
  - Quantity of sand, silt, and clay particles (gradation)
  - Particle shape (roughness)
  - Porosity (total void space "openness")
  - Moisture content (water in voids)


Units
English
SI
View
Gradation
SWCC
Dry Bulk Density
527800 kg/m3
Max. Dry Density
527800 kg/m3
Moisture Content
7.17 %
Optimum Moisture
8 %
Bulk Spec. Grav. (Gsb)
2.7
Modulus Details
SWCC Details
Calculate
Cancel
Restore Defaults
Sieve Size
Percent Passing
50.0 mm 100
25.0 mm 95
19.0 mm 85
9.50 mm 70
4.75 mm 45
2.00 mm 30
0.425 mm 25
0.075 mm 10
Material: MnDOT Class 5
Gradation
MnDOT Specification
Percent Passing
Sieve Size, mm
Saturated Hydraulic Conductivity (ksat)
0.021 mm/h
Van Genuchten/Mualem Parameters (estimated)
alpha
n

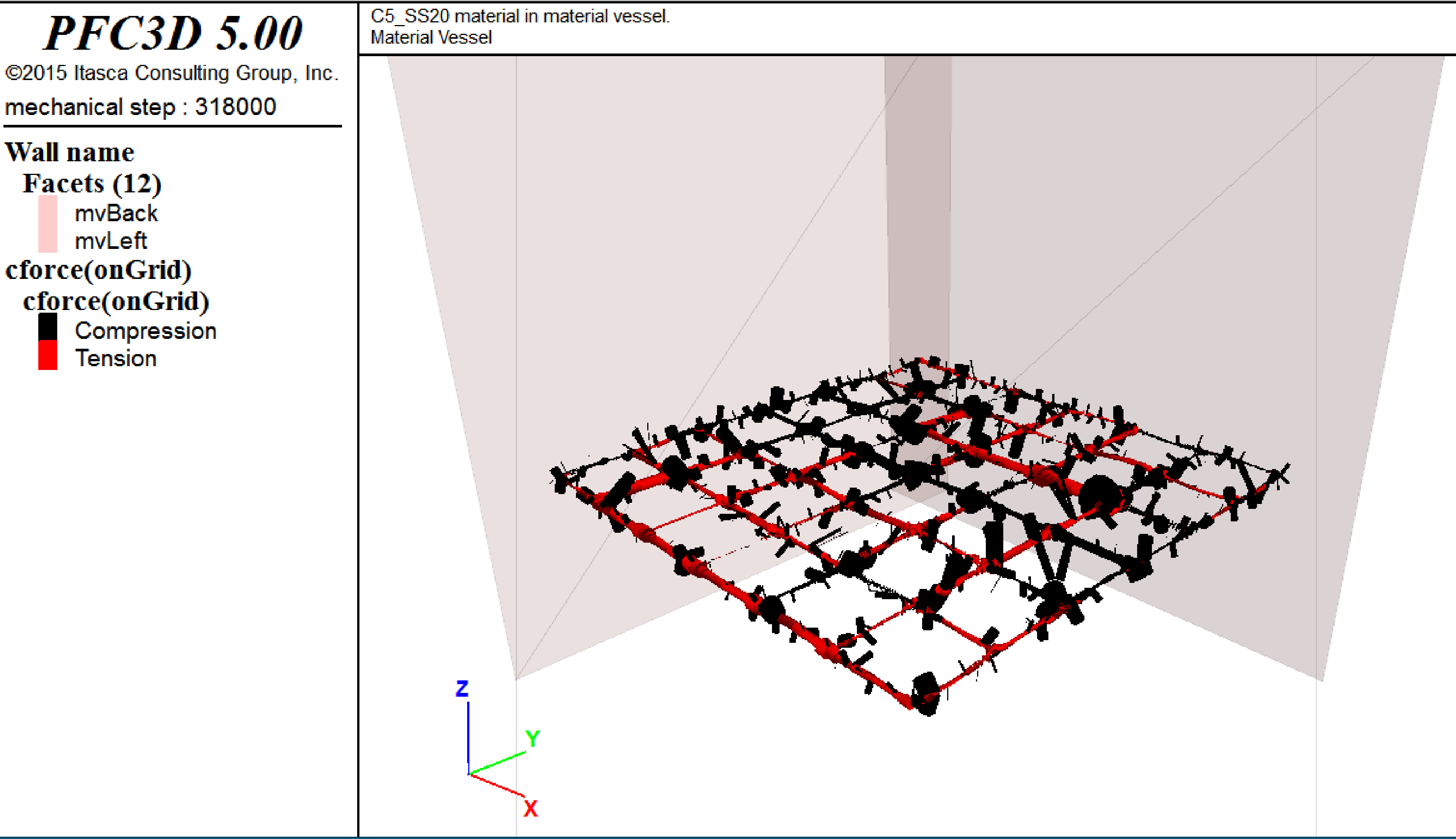

MnPAVE - Soil Water Characteristic Curve
Edit Print Window Help
Material: MnDOT Class 5
Suction (kPa)
Gravimetric Water Content
0 0.1463
0.1 0.0988
10 0.0645
30 0.0517
101 0.0448
303 0.0390
OK
Cancel
Restore Default Values
Units
English
SI
Fit Method
Brooks & Corey
Fredlund & Xing
Van Genuchten/Mualem
Sort Rows
Insert Row(s)
Delete Row(s)


Moisture Content
7.17 %
Optimum Moisture
8 %
Grav. (Gsb)
2.7
SWCC Details
Cancel
Restore Defaults
Material: MnDOT Class 5
SWCC
Degree of Saturation
Suction, kPa
0.021 mm/h
Van Genuchten/Mualem Parameters (estimated)
alpha
n

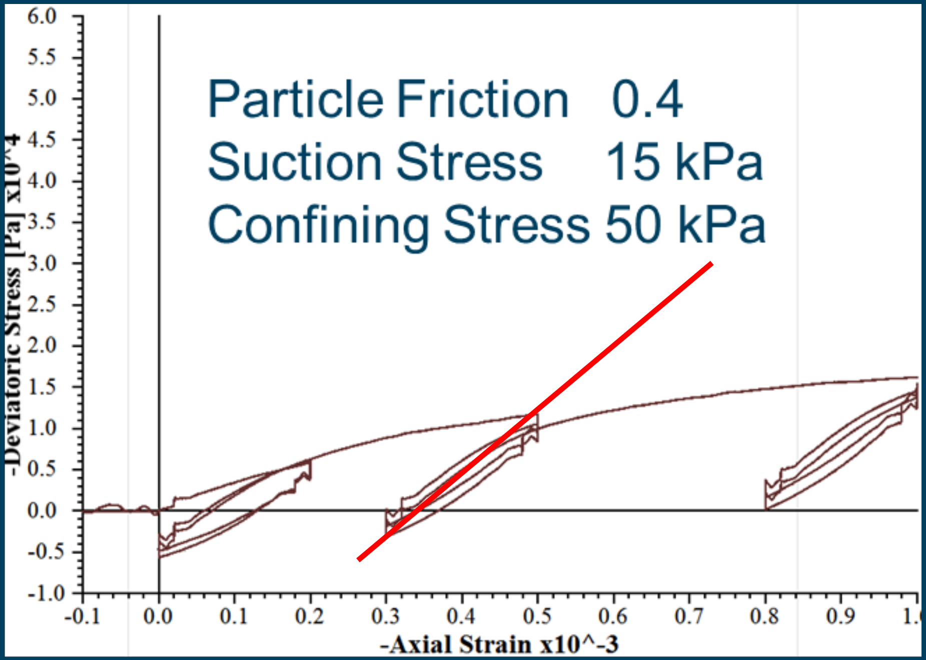

Water Retention Curve
Gravimetric Water Content (%)
Suction (kPa)

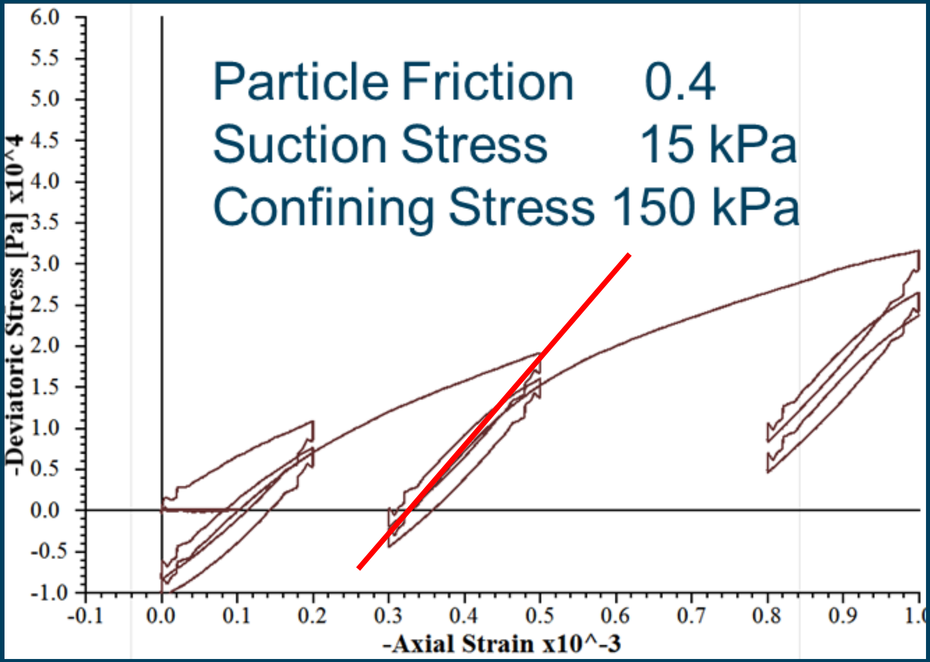

Z
Y
X

Grid with Red Showing Tension



Numerical Simulation Results
(aggregate base only)

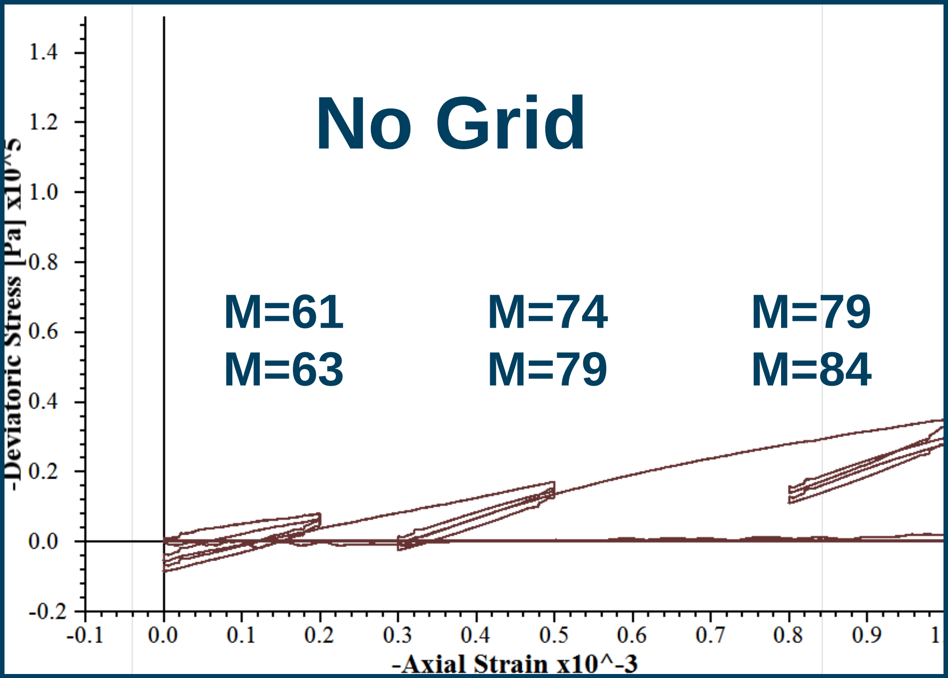


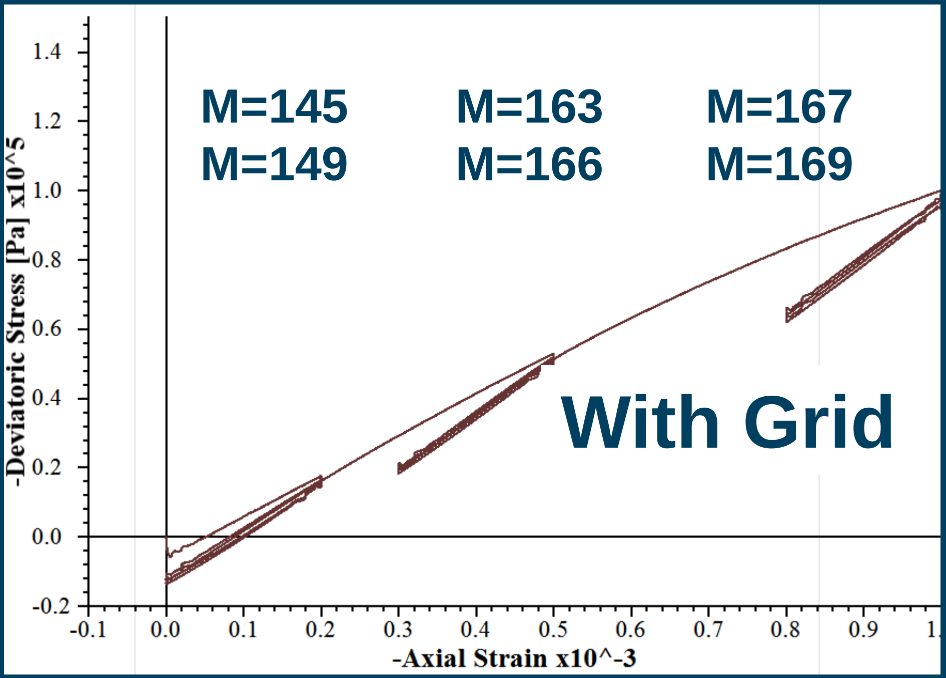


Increasing confining stress increases resilient modulus.

Modulus of 8 Inch Aggregate Base Layer

Confinement = 150 kPa Particle Friction = .8 Moisture Tension = 1 kPa (gap 3 mm)





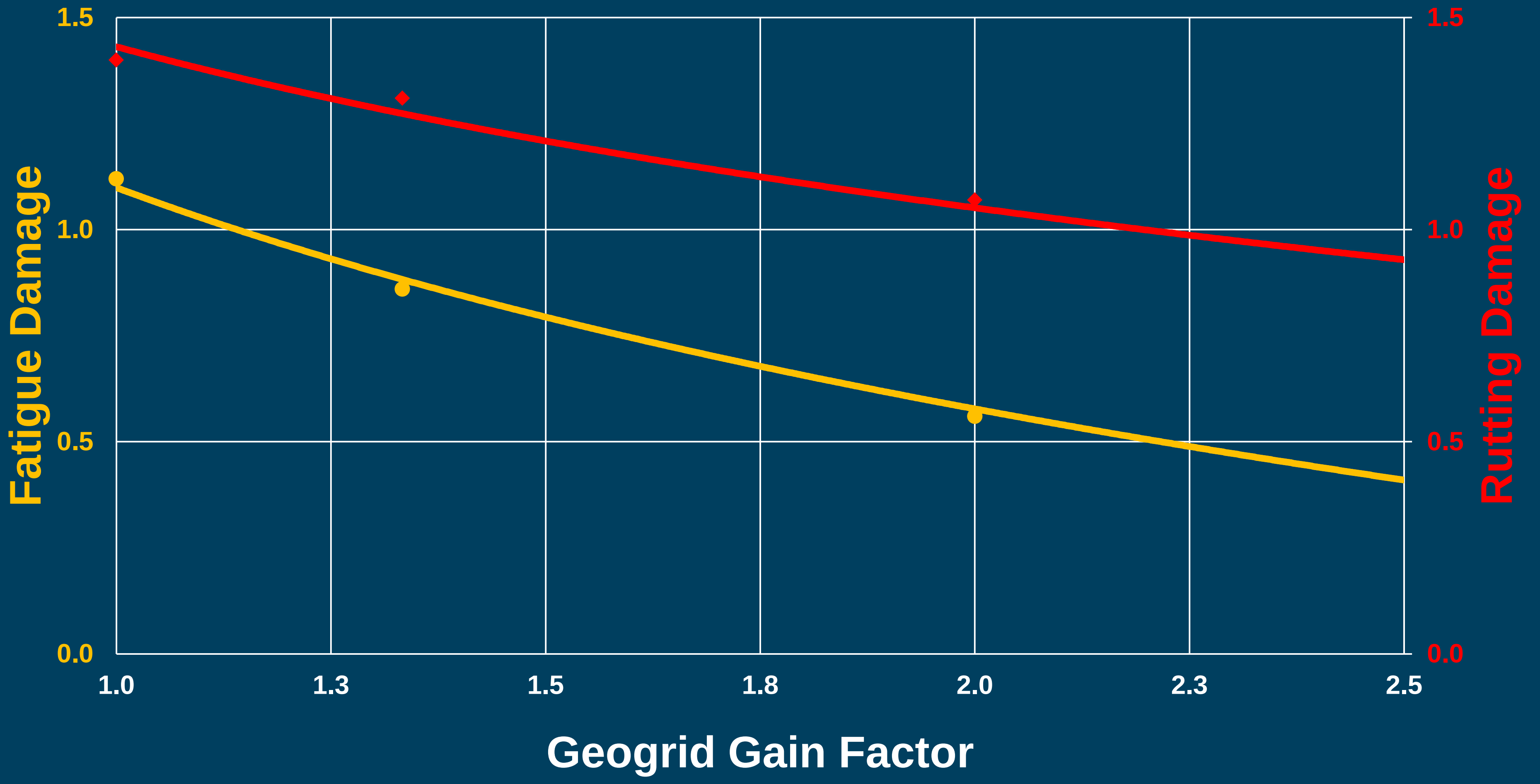
Geogrid Gain Factors

(at axial strain)

0.02%	0.05%	0.1%
2.4	**2.2**	**2.1**
2.4	**2.1**	**2.0**

Damage vs Geogrid Gain Factor

Damage must be less than of 1.0 for 20 year design.



Thank you.

Questions?