Performance Models

Pavement Design Systems and Pavement Performance Models
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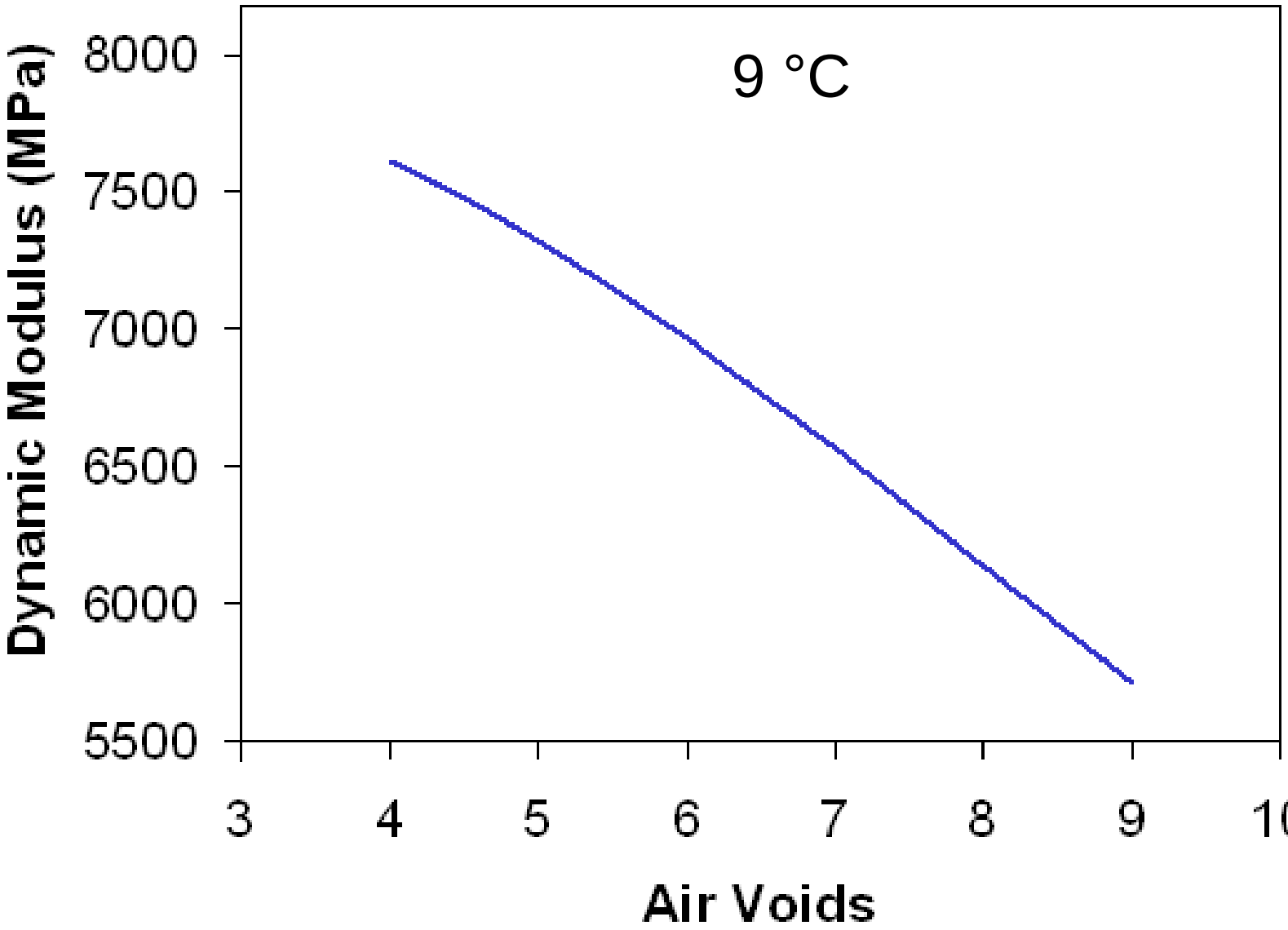
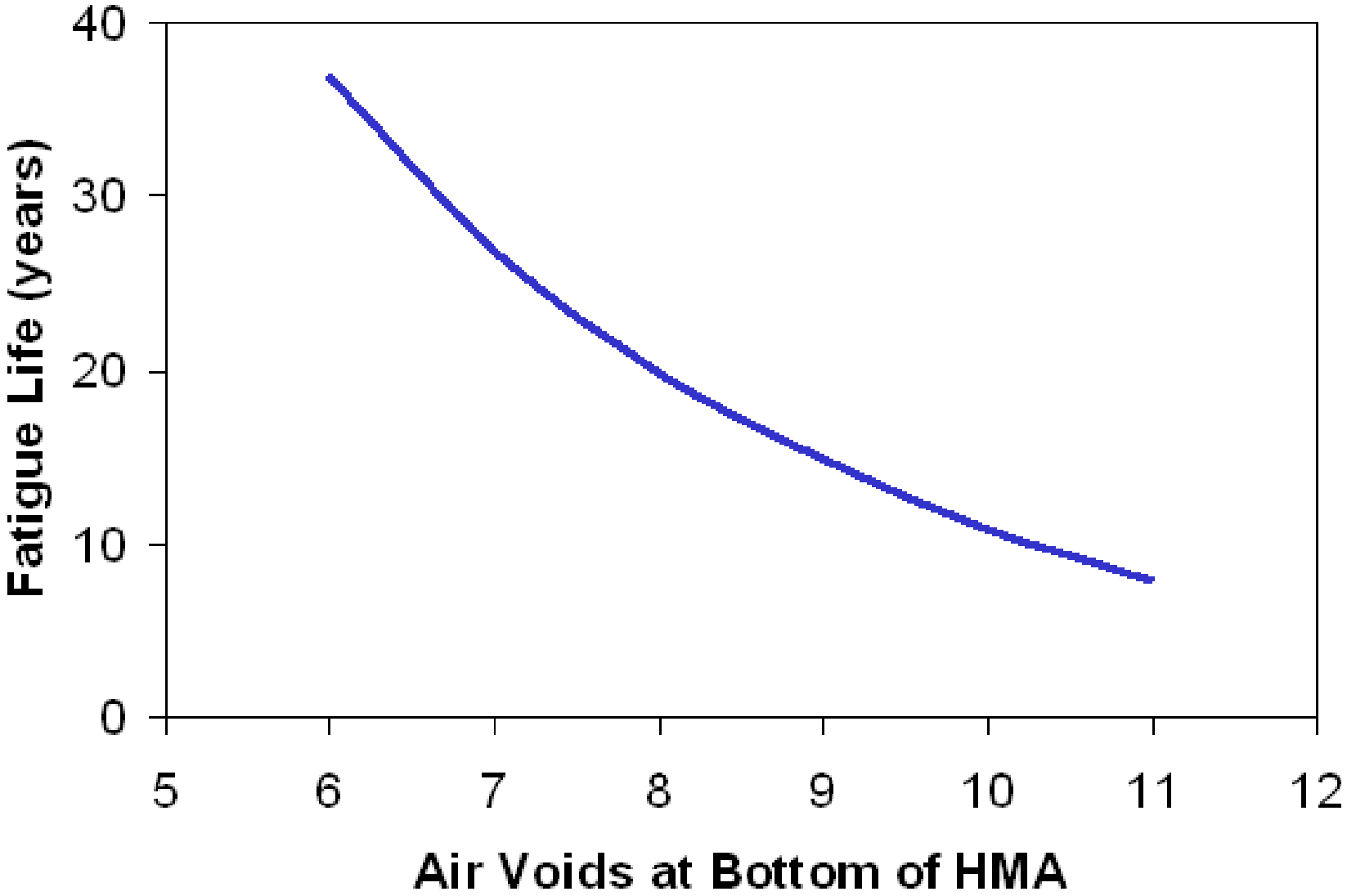
Effect of Air Voids on Dynamic Modulus



Effect of Air Voids on Fatigue Life



Validation/Calibration Process

1. Compare MnPAVE output with current procedure and experience
2. Analyze reasonableness of predicted performance, adjust if necessary
3. Compare MnROAD performance

MnPAVE – Calibration

- Fatigue and rutting transfer functions
- Not many failures in Minnesota
- Preliminary calibration based on R-Value designs

Miner's Hypothesis

$$Damage = \sum_{i=1}^{k} \sum_{j=1}^{m} \frac{n_{season_i, load_j}}{N_{season_i, load_j}}$$

Where:

n = applied load repetitions

N = allowed load repetitions

k = total number of seasons

m = number of load configurations

Damage $\geq$ 1 indicates failure

Transfer Functions: Fatigue

Fred Finn/Asphalt Institute model

$$N = C \times S \times \left(4.32 \times 10^{-3}\right) \varepsilon^{-3.291} E^{-0.854}$$

Where

N **= Allowed load repetitions for fatigue**

S **= Shift factor***

ε **= Tensile strain at bottom of HMA**

E **= HMA dynamic modulus (MPa)**

C **= correction factor based on air voids and binder content**

*** Preliminary MnPAVE shift factor of 92.6 is based on calibration with existing R-Value designs.**

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Transfer Functions: Rutting

Calibrated with existing R-Value designs

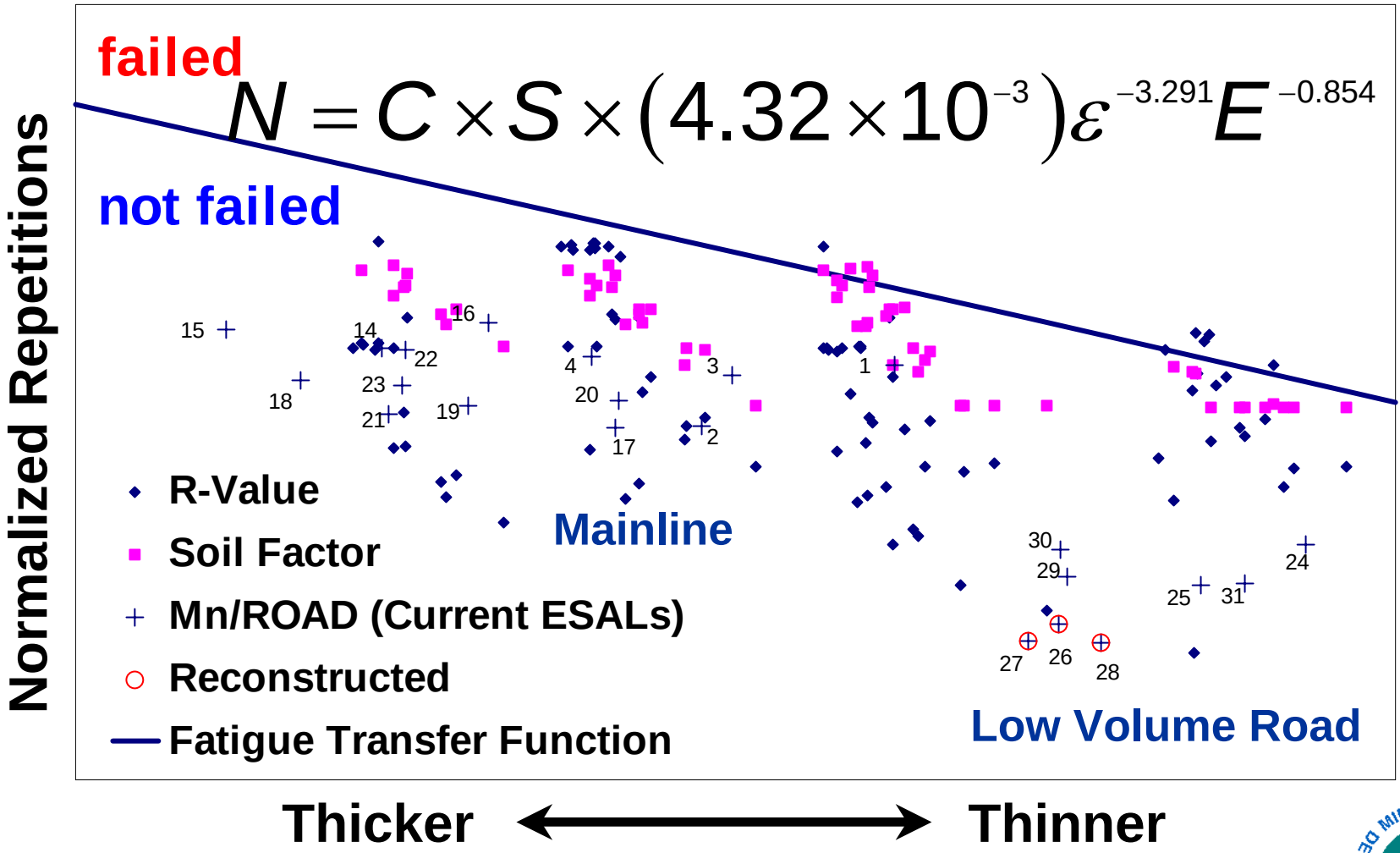
$$N = 0.00618\,\varepsilon^{-2.5592}$$

Where

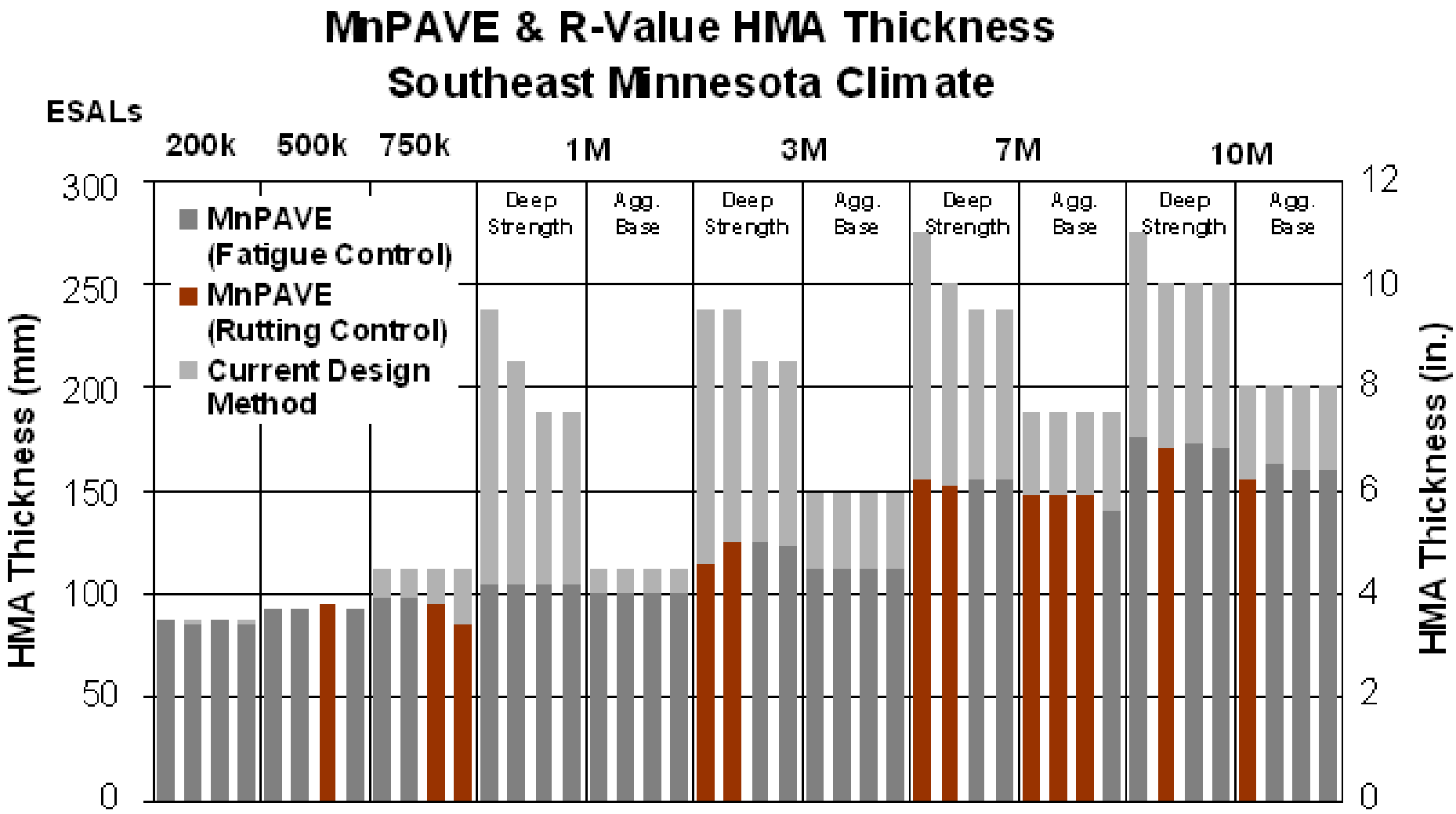
***N* = Allowed load repetitions for rutting**

ε = vertical strain at top of subgrade

R-Value Fatigue Calibration (2002)

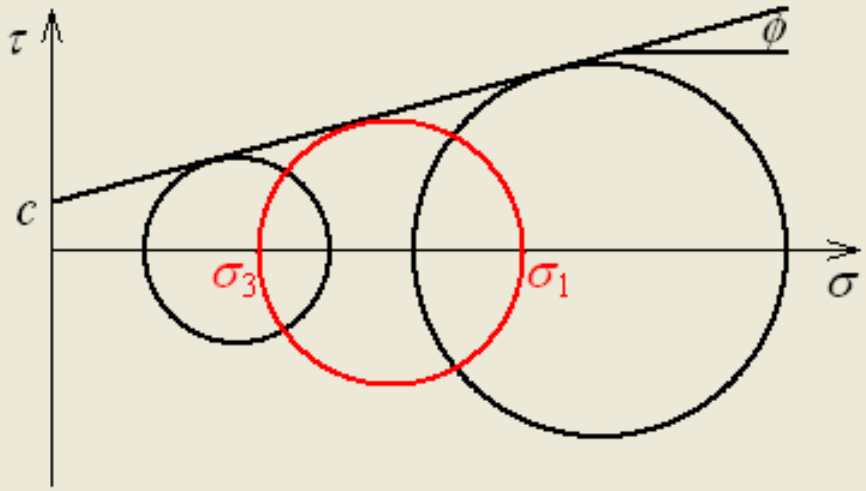


MnPAVE Calibration



MnPAVE - Mohr-Coulomb Criterion

Print Window Help



OK

Cancel

Material: Mn/DOT Class 6

$$\sigma_1 < \sigma_{1\,critical} = \sigma_3 \times \tan^2\left(45 + \frac{\phi}{2}\right) + 2c \times \tan\left(45 + \frac{\phi}{2}\right)$$

c 41.4 kPa

ϕ 24 °

Where:

$\sigma_{1\,critical}$ = Maximum allowed stress at middle of aggregate base

σ_1 , σ_3 = Principal stresses due to maximum axle load

c = Cohesion of granular material (from triaxial test)

ϕ = Friction angle of granular material (from triaxial test)

Note:
Currently all default values are derived from tests performed on Class 5 aggregate.
Values for other materials will be added when testing is complete.

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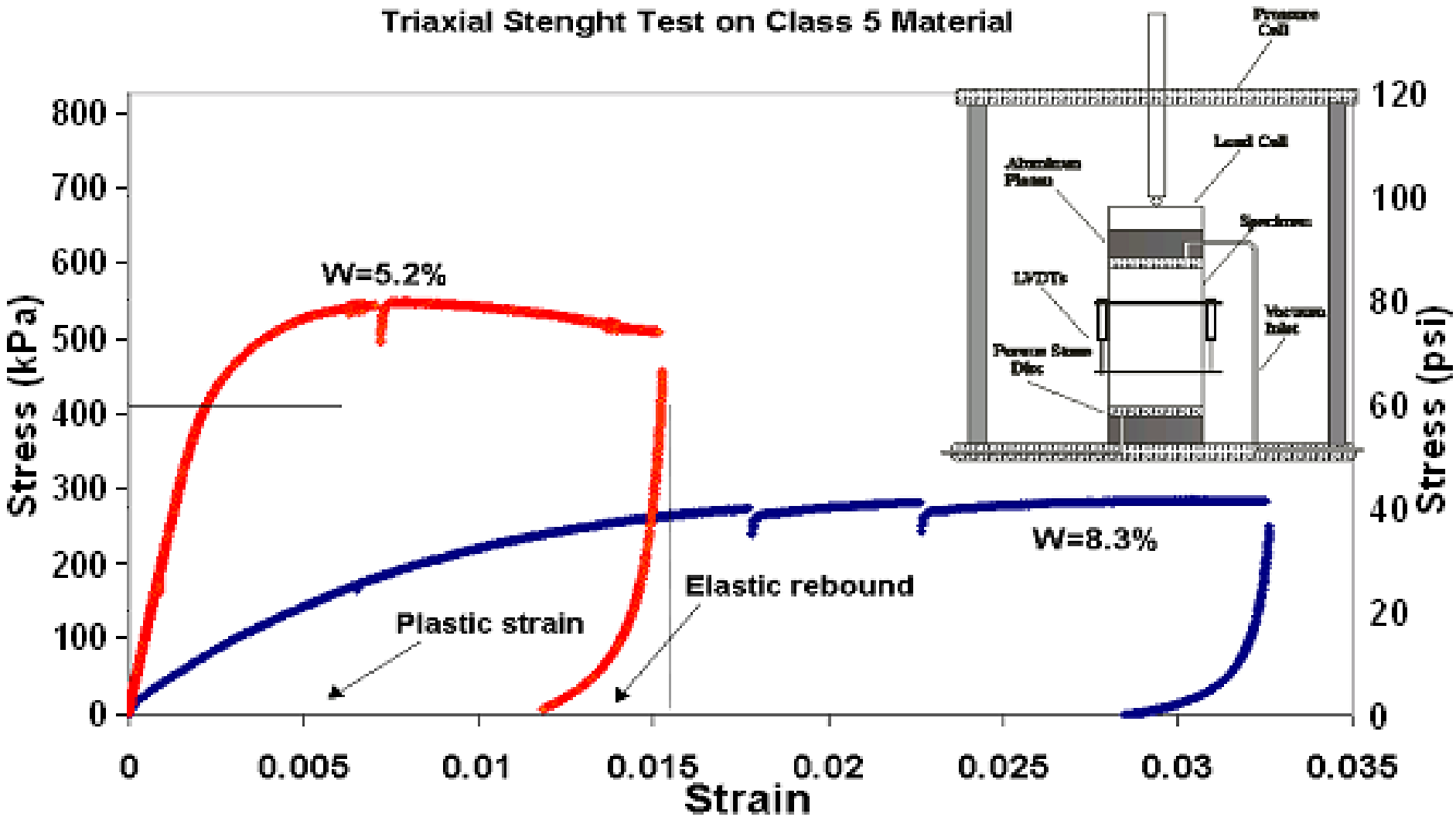
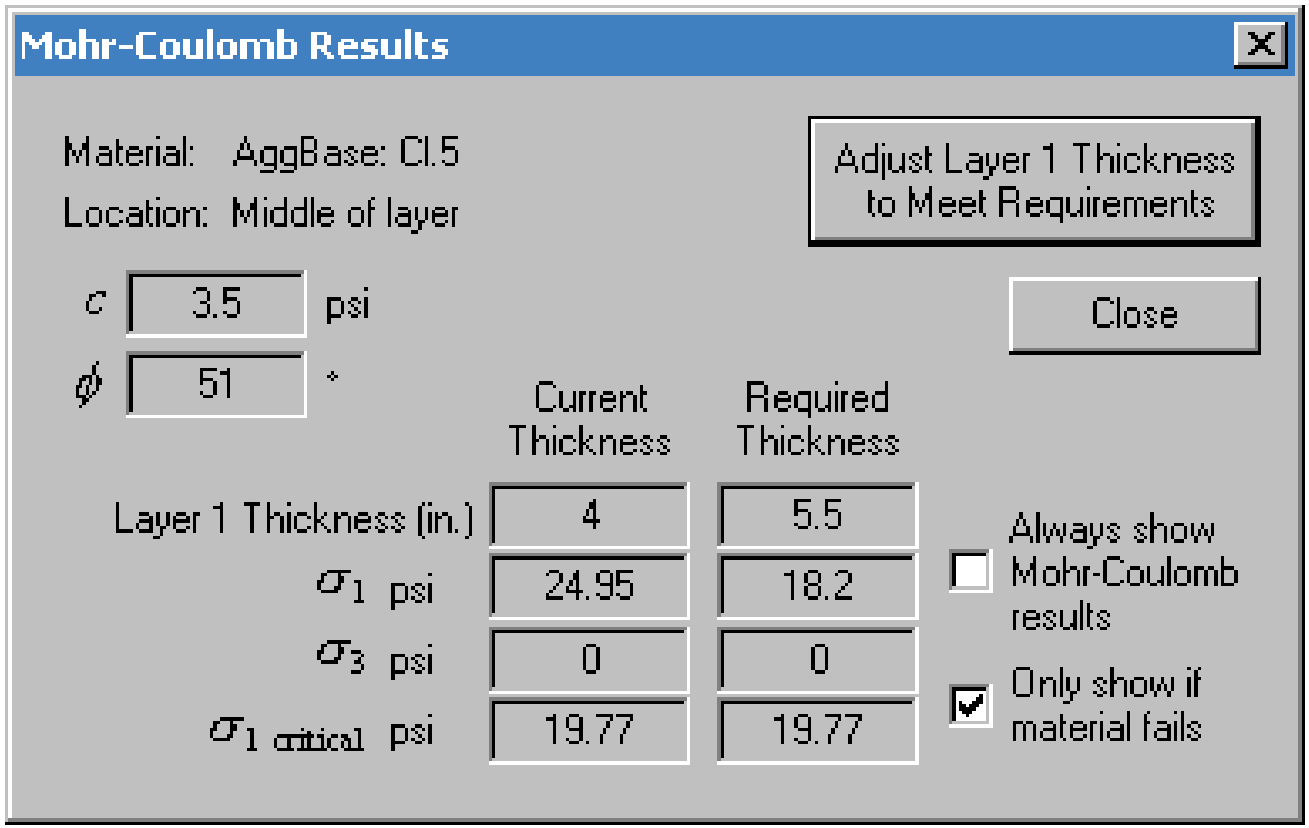
Triaxial Test

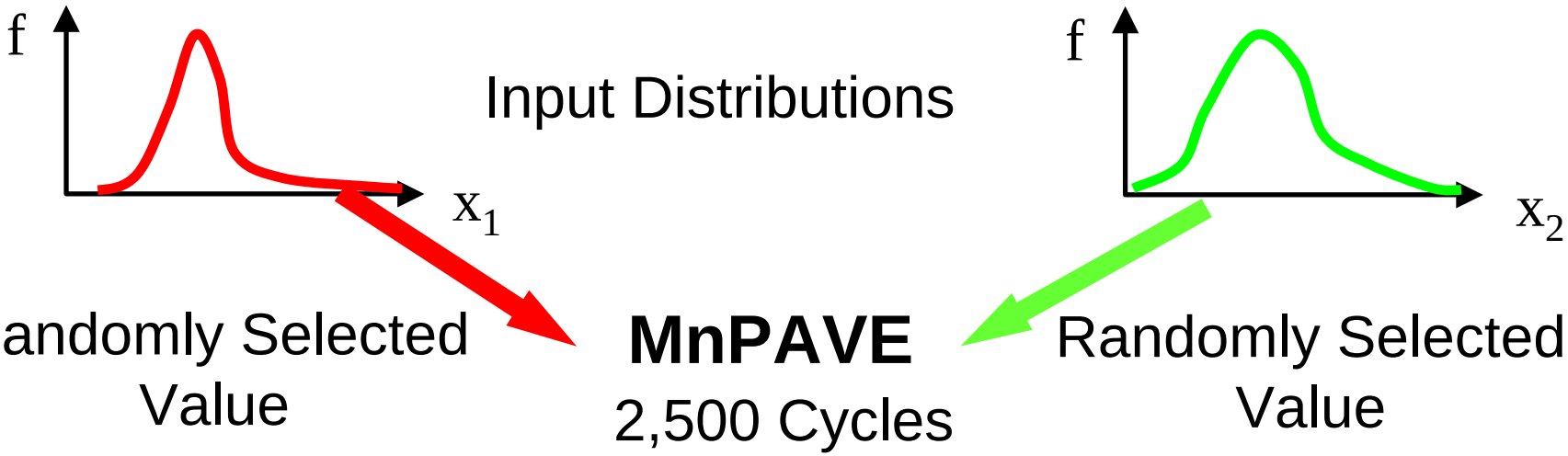
Allowable stress criteria for aggregate base



MnPAVE Mohr-Coulomb Results

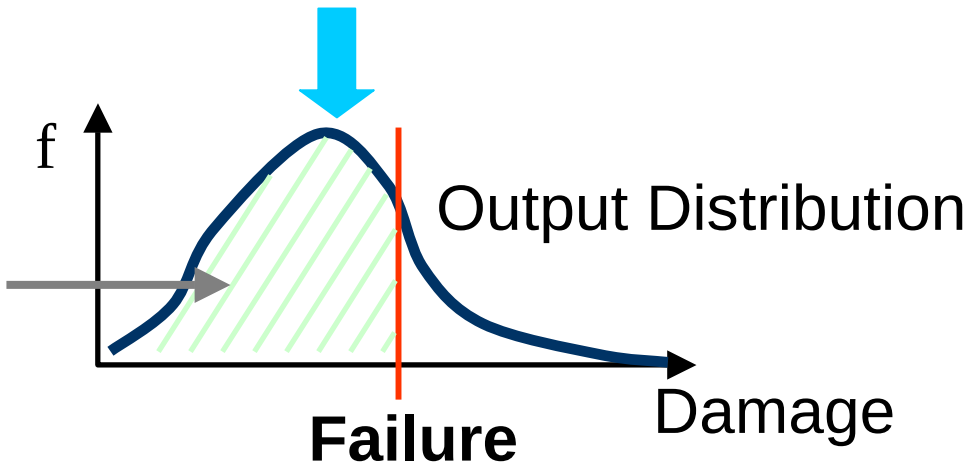


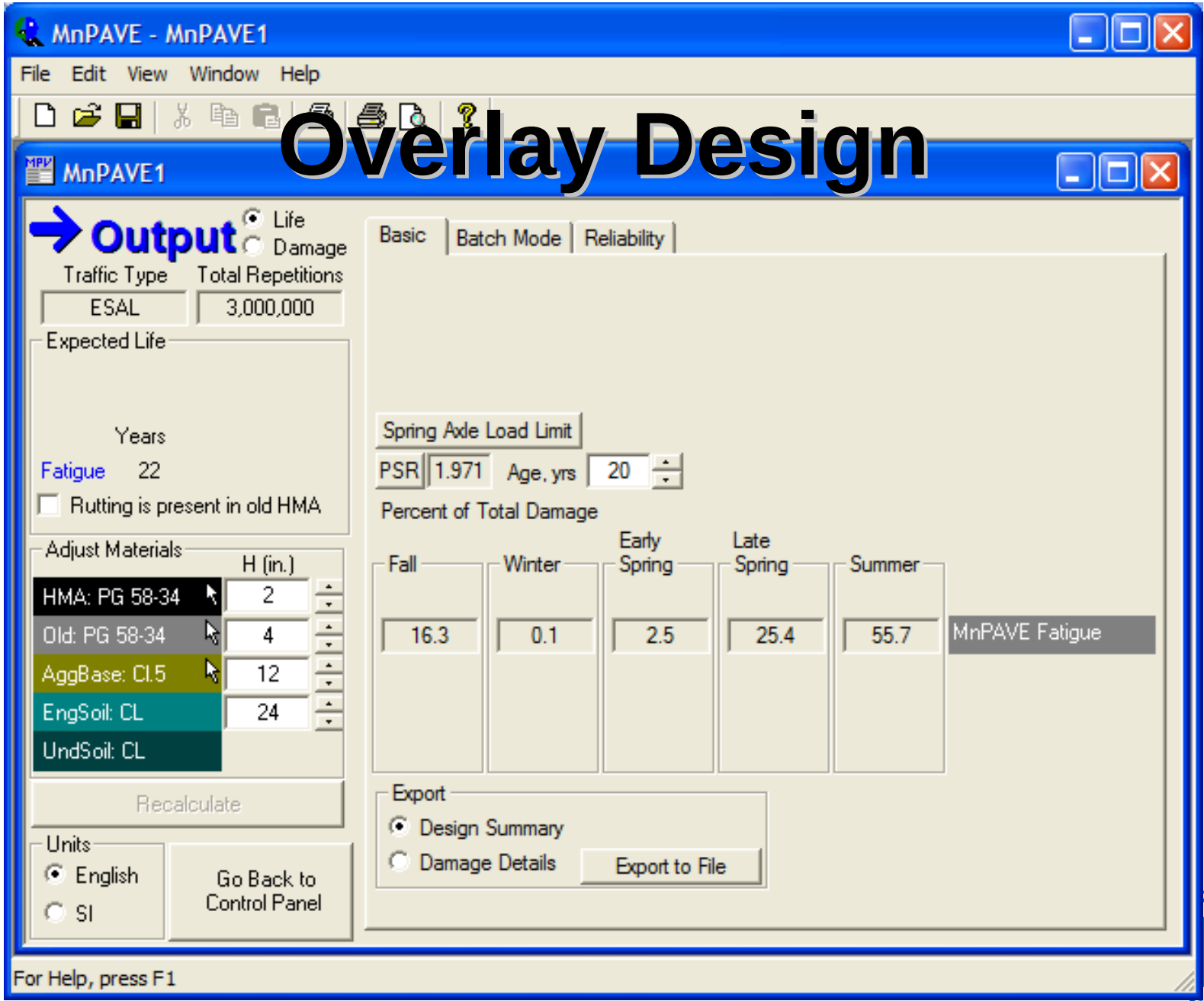
Monte Carlo Simulation



Reliability

P(Damage < 1)




MnPAVE - MnPAVE1
File Edit View Window Help
MnPAVE1
Overlay Design
Output
Life
Damage
Traffic Type
ESAL
Total Repetitions
3,000,000
Expected Life
Years
Fatigue 22
Rutting is present in old HMA
Adjust Materials
H (in.)
HMA: PG 58-34
2
Old: PG 58-34
4
AggBase: Cl.5
12
EngSoil: CL
24
UndSoil: CL
Recalculate
Units
English
SI
Go Back to Control Panel
Basic
Batch Mode
Reliability
Spring Axle Load Limit
PSR
1.971
Age, yrs
20
Percent of Total Damage
Fall
Winter
Early Spring
Late Spring
Summer
16.3
0.1
2.5
25.4
55.7
MnPAVE Fatigue
Export
Design Summary
Damage Details
Export to File
For Help, press F1

Lukanen Report: Pavement Performance Prediction Models 1992

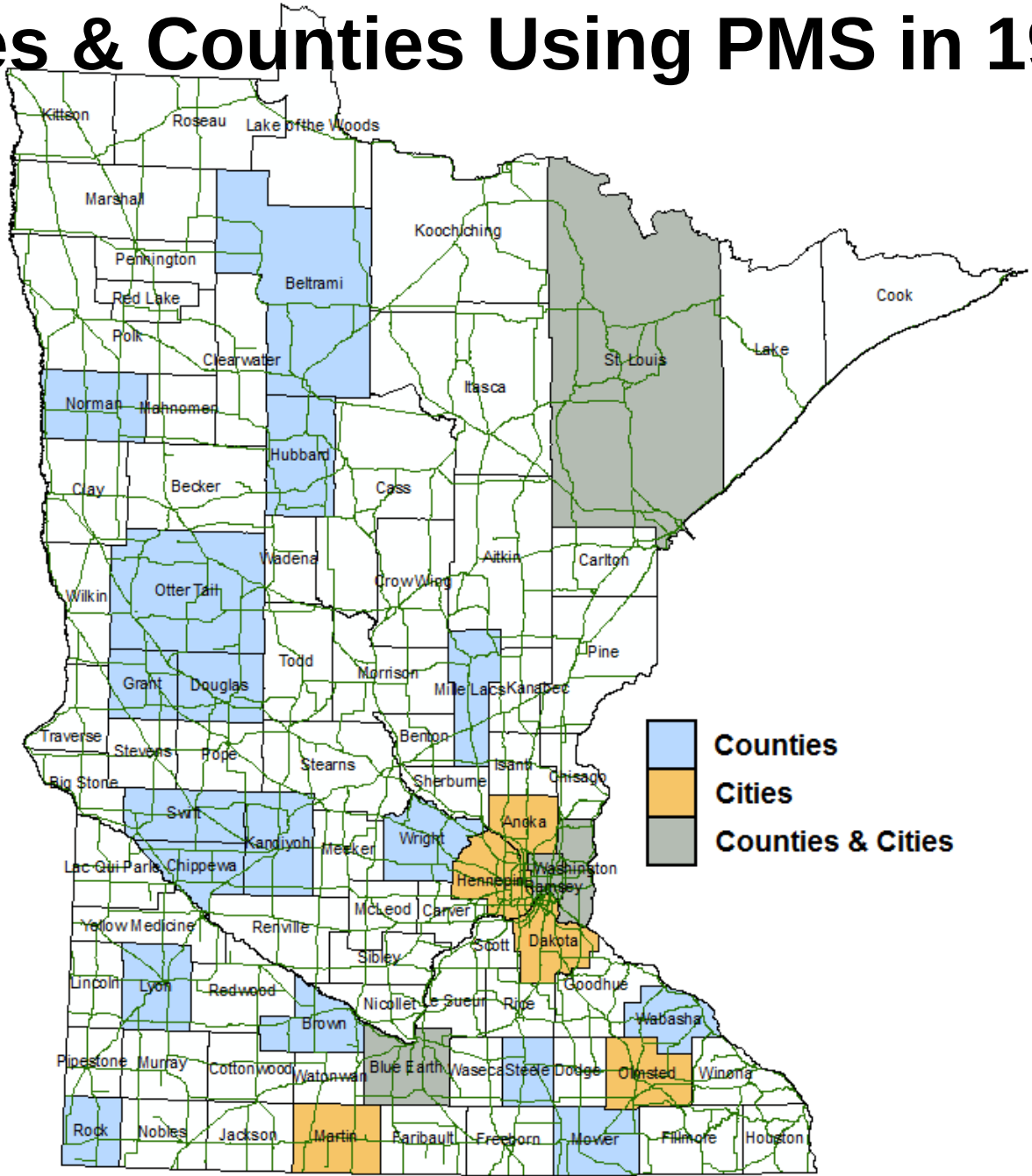
$$PSR = PSR_{initial} - e^{\left(a - b \times c^{t}\right)}$$

Where:

$$t = \ln\left(\frac{1}{Age}\right)$$

LRRB 828

Cities & Counties Using PMS in 1998



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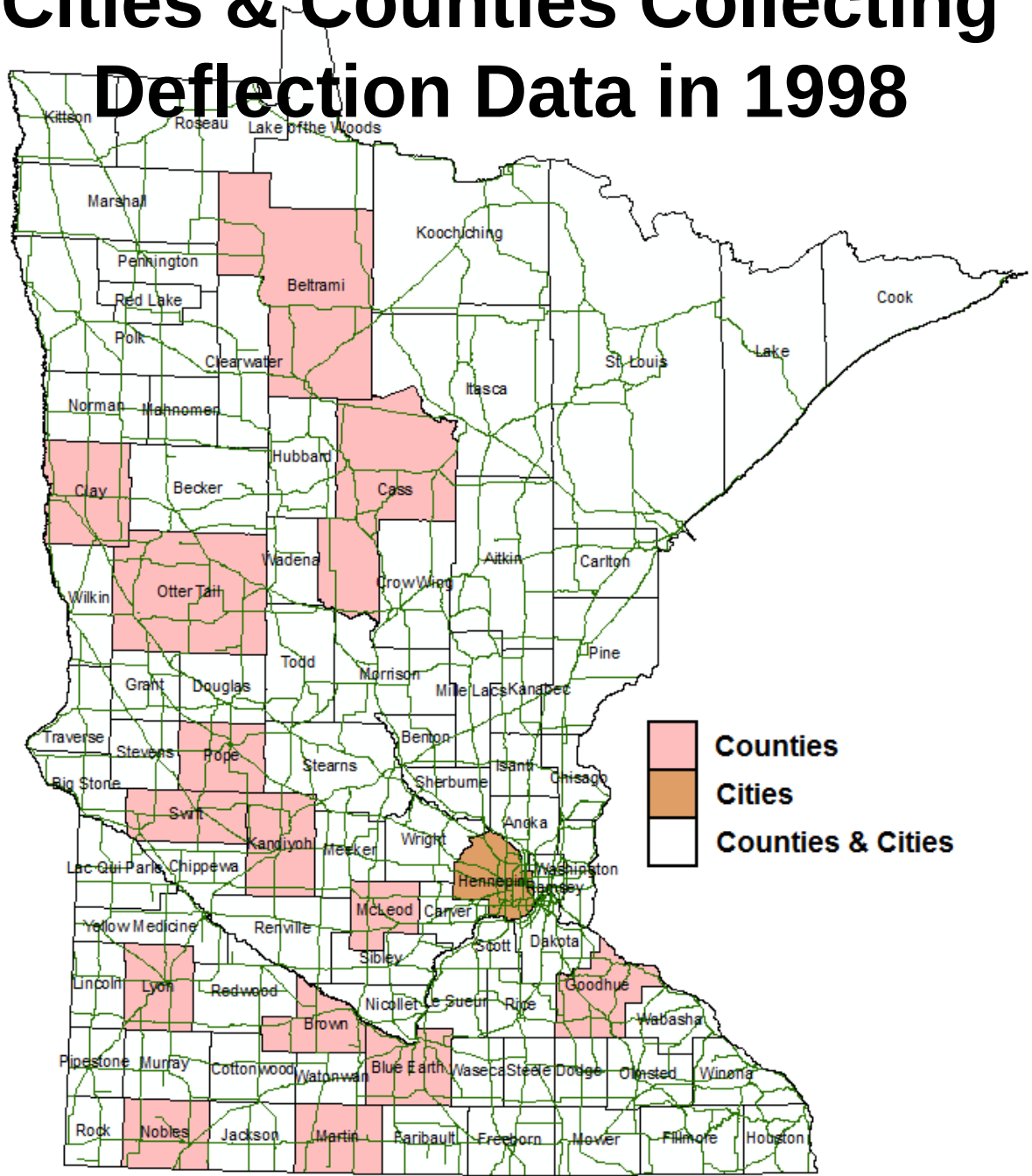
Cities & Counties Collecting Deflection Data in 1998



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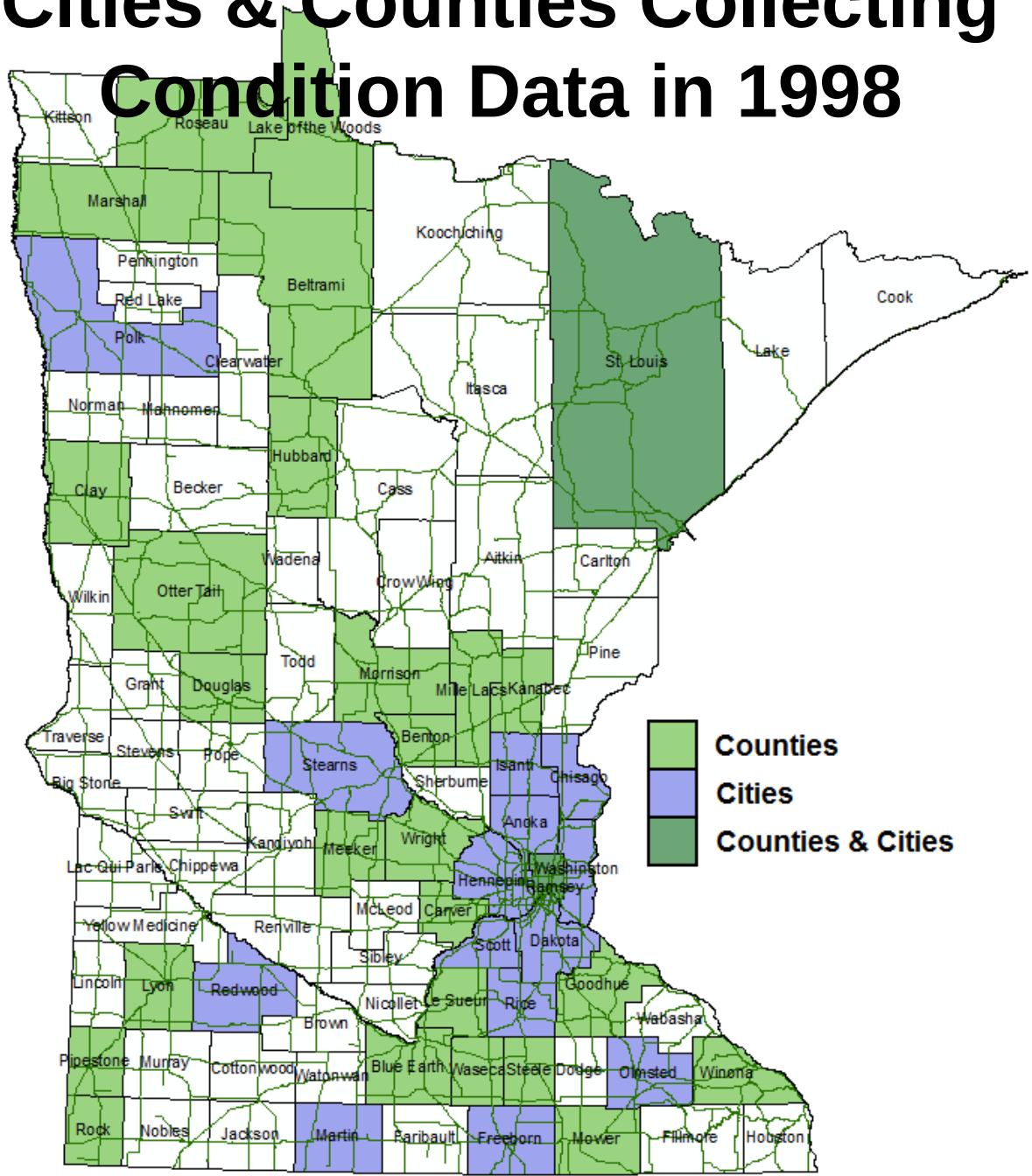
Cities & Counties Collecting Condition Data in 1998



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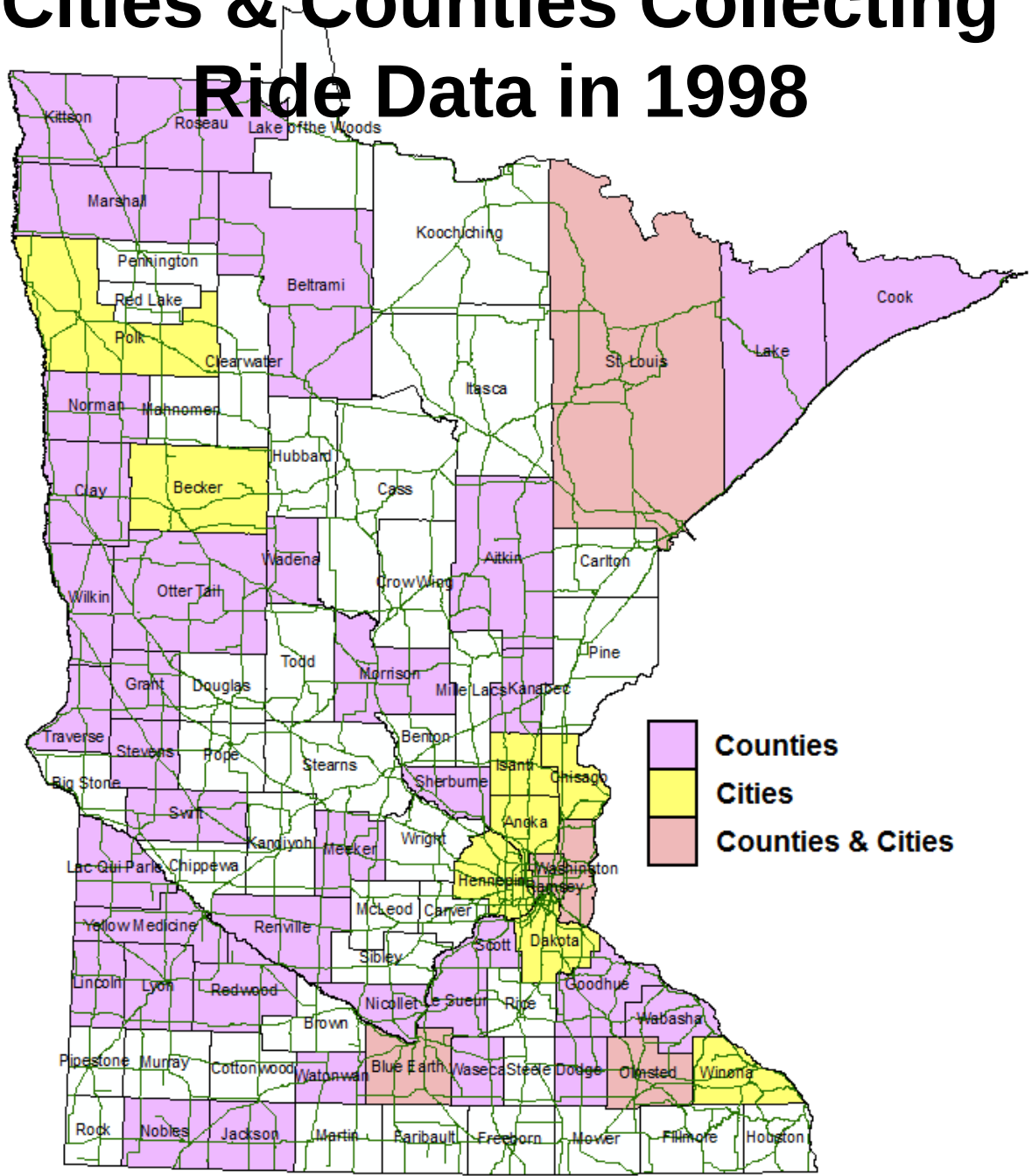
Cities & Counties Collecting Ride Data in 1998



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Other Development Tools

- GIS – Geographic Information System
  - Roads
  - Soils
  - Groundwater
- MPS – Materials Performance System
  - Soil and Aggregate Test Results
  - Pavement History
  - FWD
  - Traffic

Future Work

- Refine transfer functions
- Expand procedure to cover rehabilitation
  - Overlays
  - CIR
  - Rubblization
- Performance specifications
- Further work needed to characterize modified base gradations, select granular, Superpave, etc.

Questions

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