Performance Models

Pavement Design Systems and Pavement Performance Models
March 22-23, 2007 - Reykjavik, Iceland

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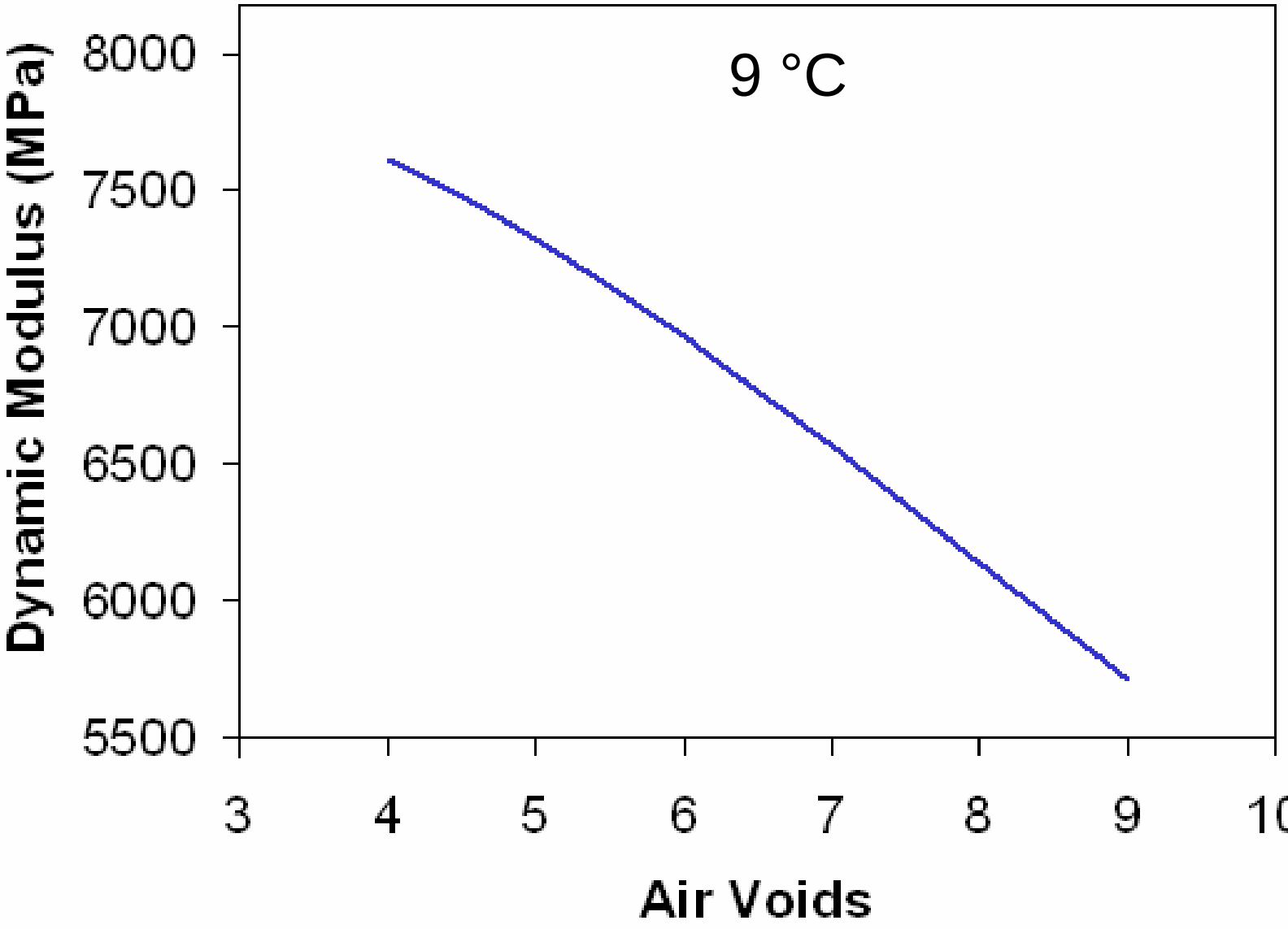
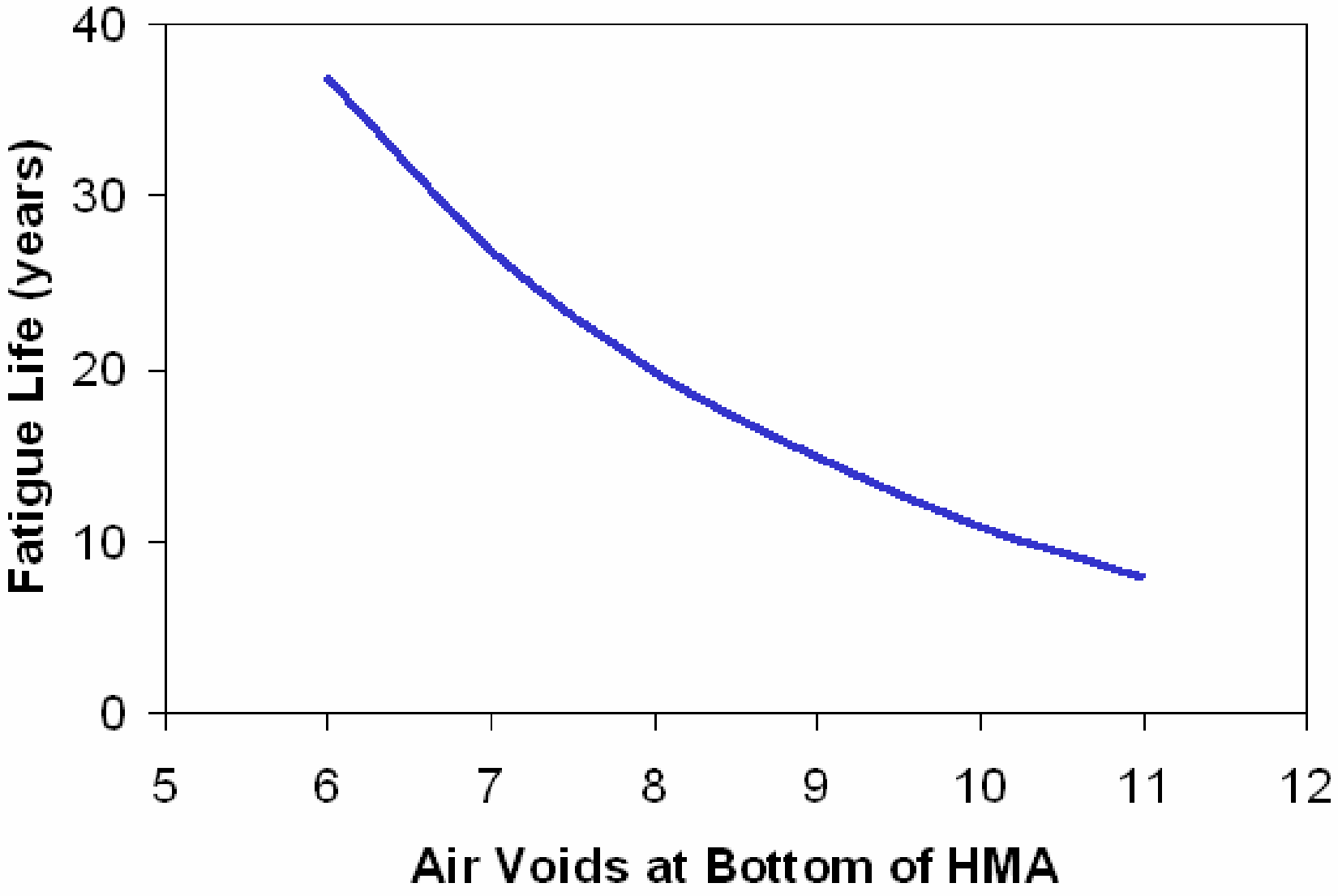
Effect of Air Voids on Dynamic Modulus



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 N. 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

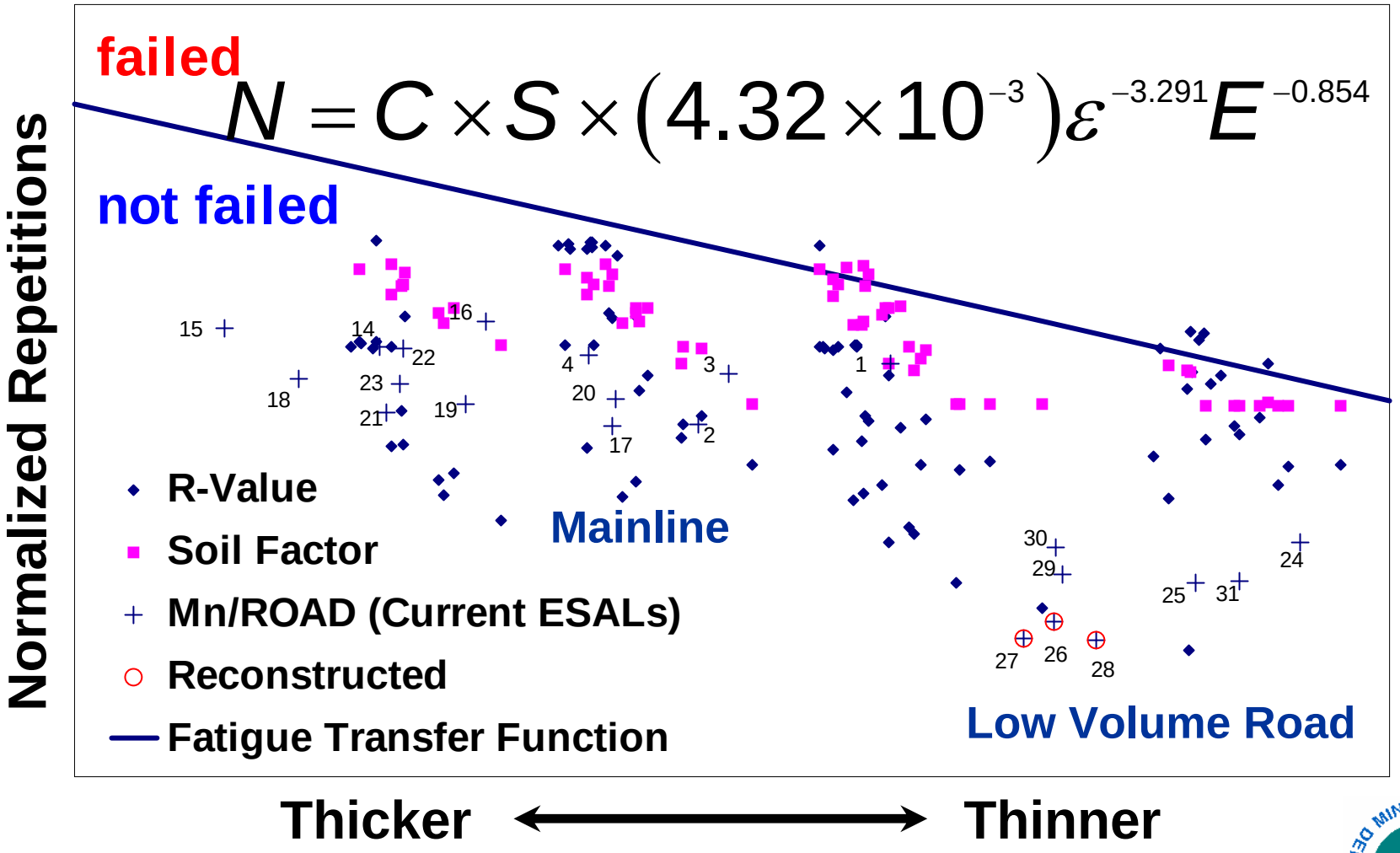
$$N = 0.00618\,\varepsilon^{-2.5592}$$

Where

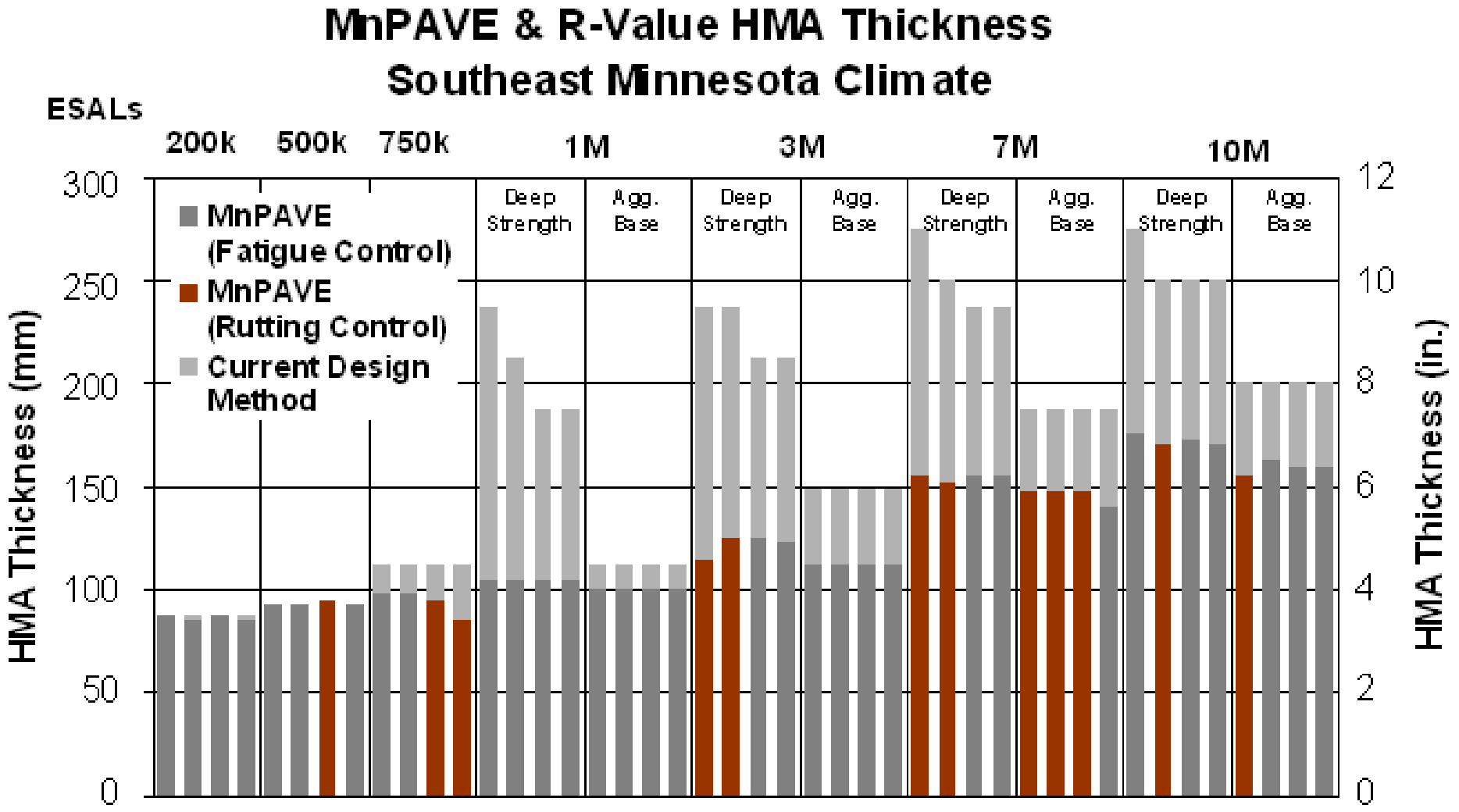
N **= Allowed load repetitions for rutting**

ε **= vertical strain at top of subgrade**

R-Value Fatigue Calibration (2002)

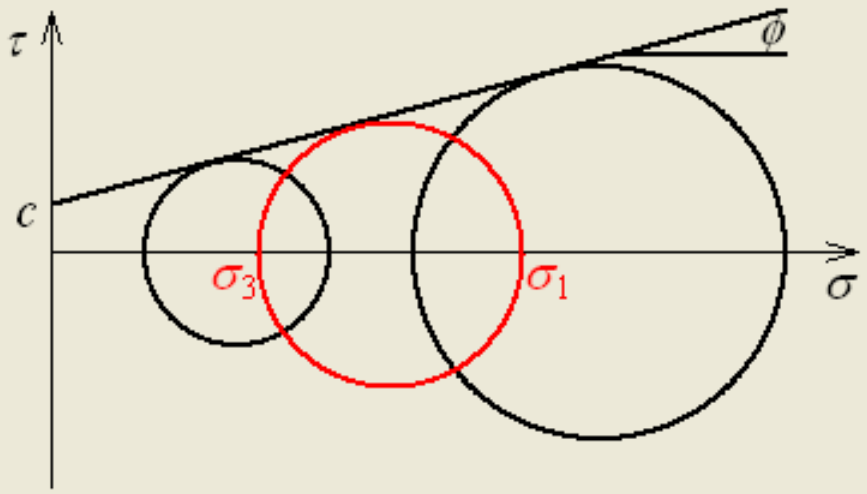


MnPAVE Calibration



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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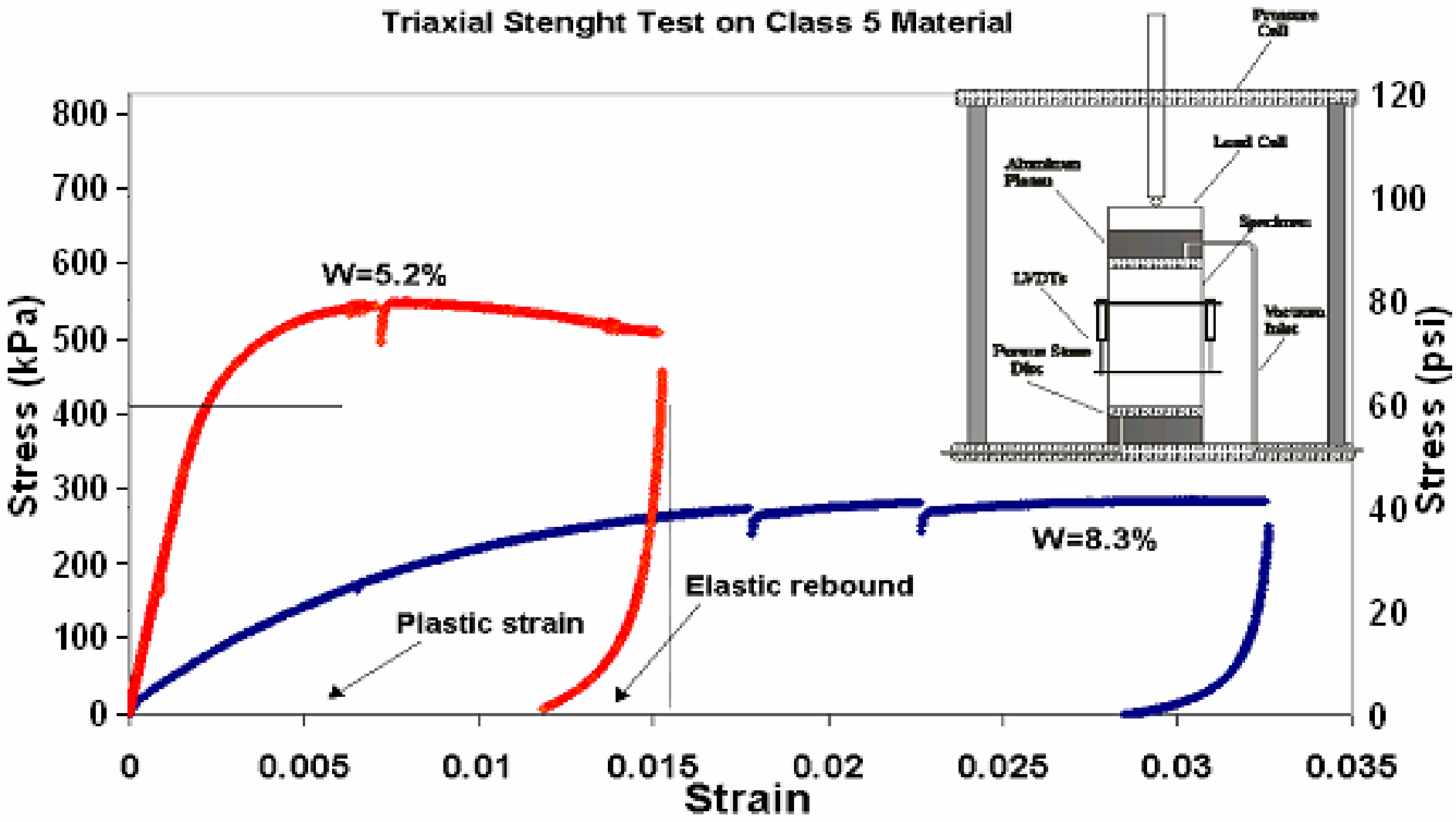
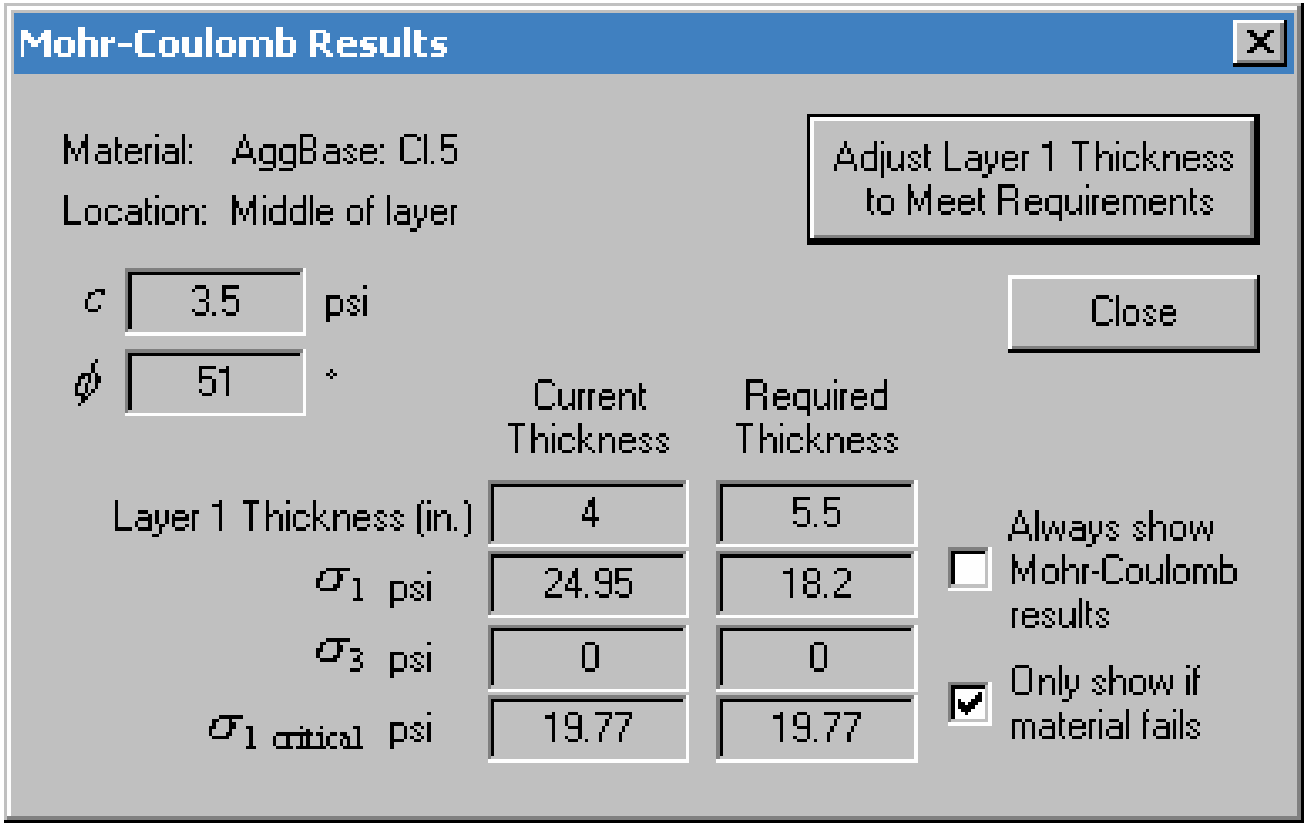
Triaxial Test

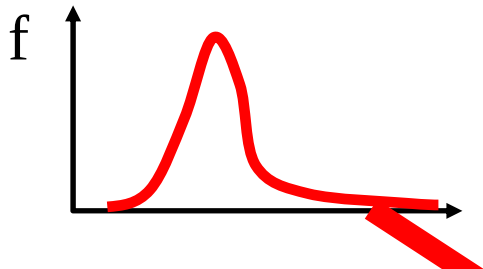
Allowable stress criteria for aggregate base



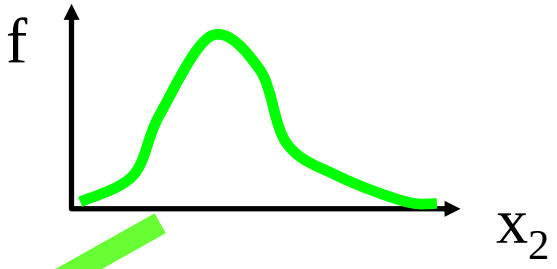
MnPAVE Mohr-Coulomb Results



Monte Carlo Simulation



Input Distributions



Randomly Selected Value

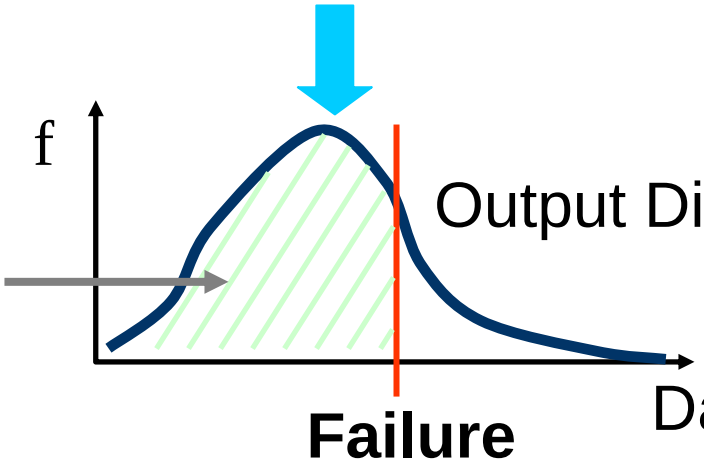
MnPAVE

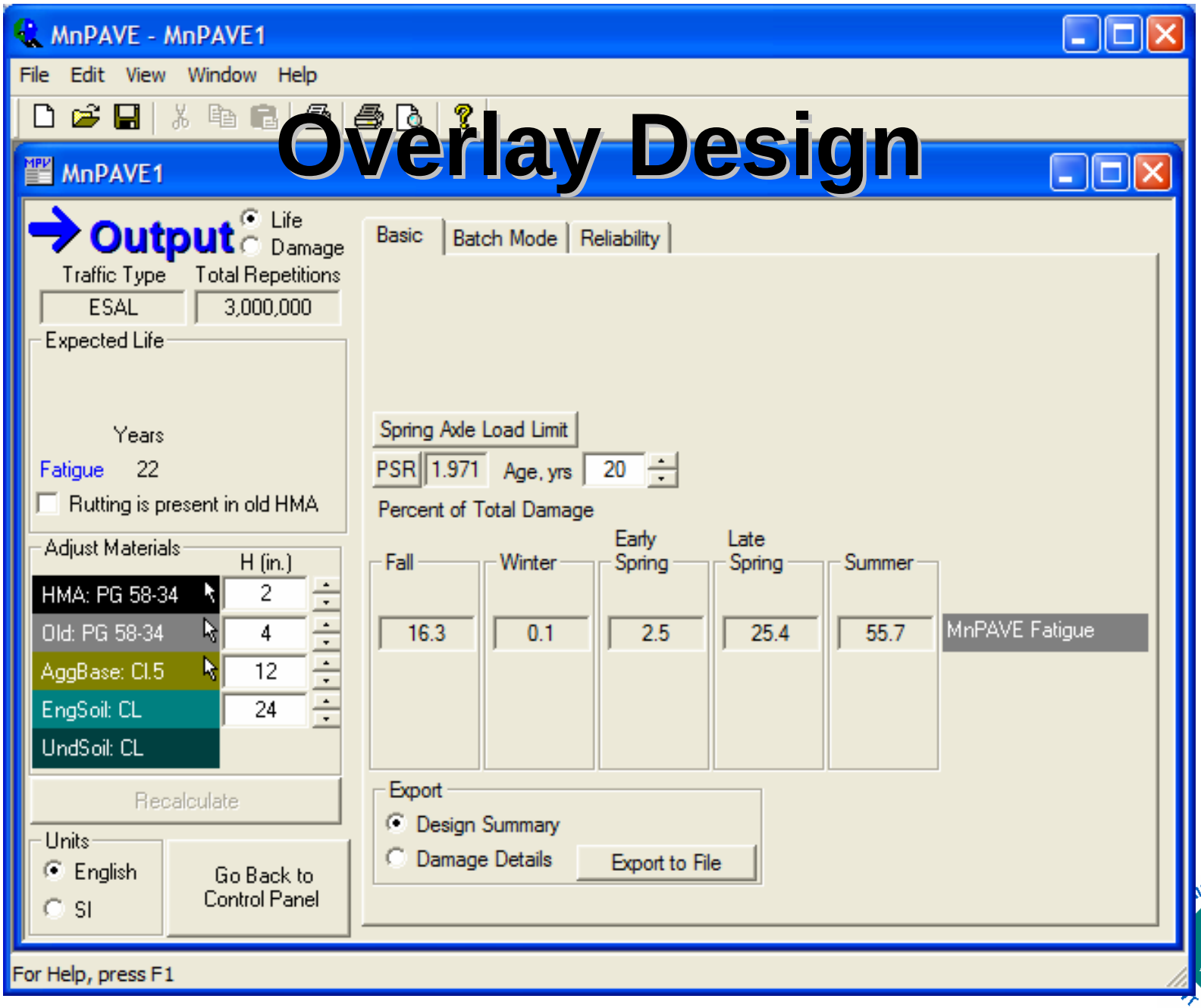
2,500 Cycles

Randomly Selected Value

Reliability

P(Damage < 1)





Overlay Design

Lukanen Report: Pavement Performance Prediction Models 1992

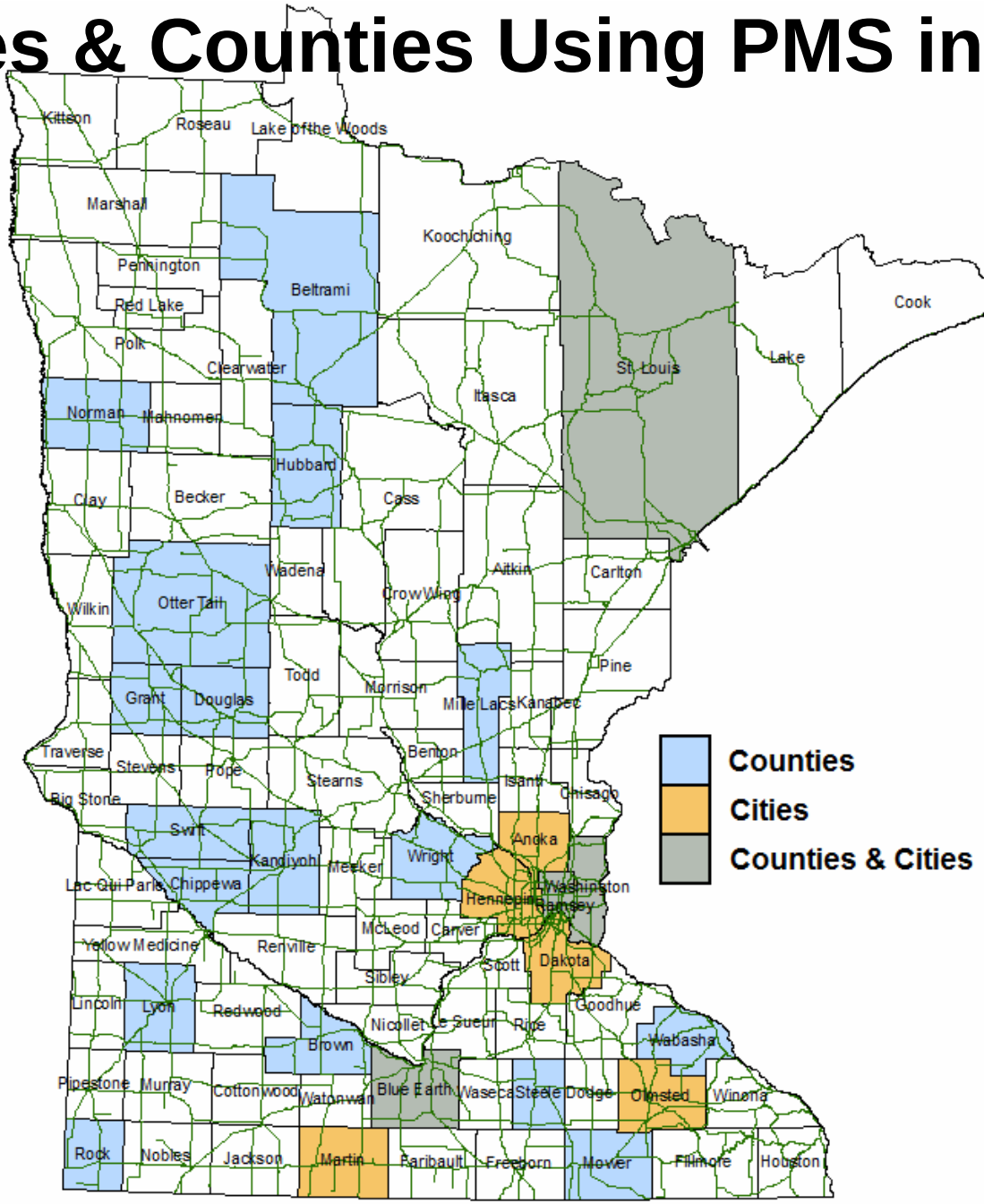
$$PSR = PSR_{initial} - e^{\left(a - b \times c^{t}\right)}$$

Where:

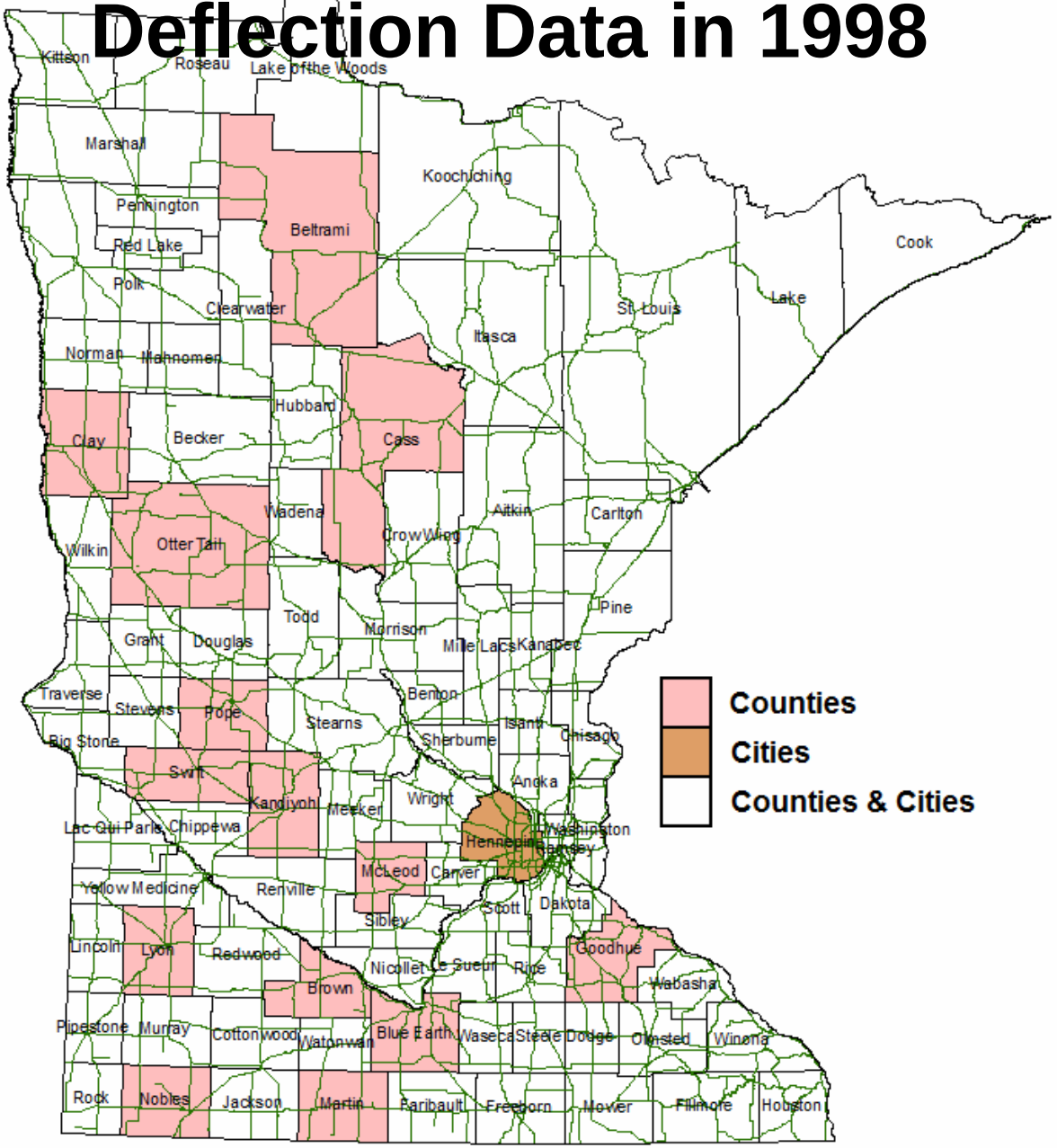
$$t = \ln\left(\frac{1}{Age}\right)$$

LRRB 828

Cities & Counties Using PMS in 1998



Cities & Counties Collecting Deflection Data in 1998



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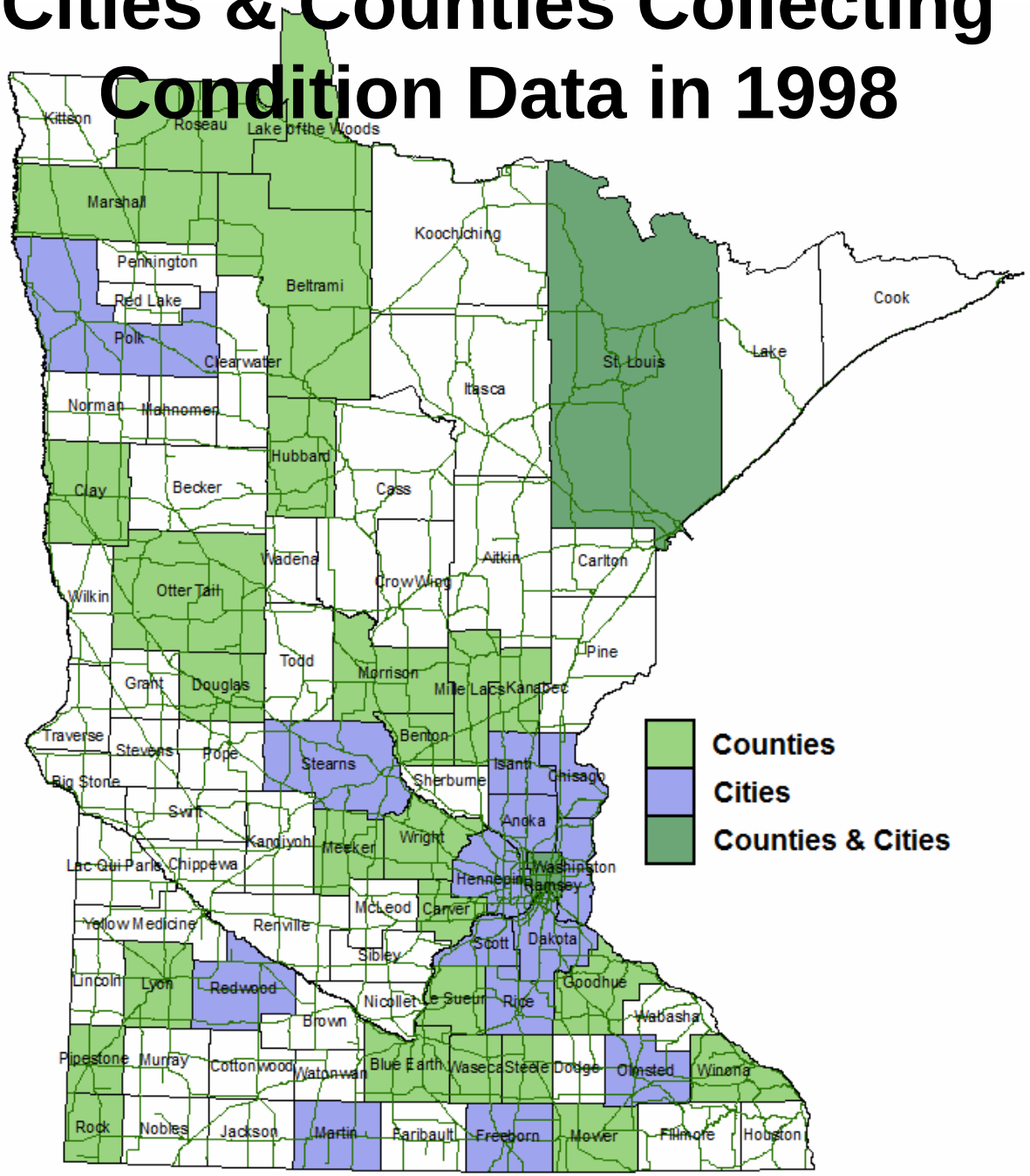
Cities & Counties Collecting Condition Data in 1998



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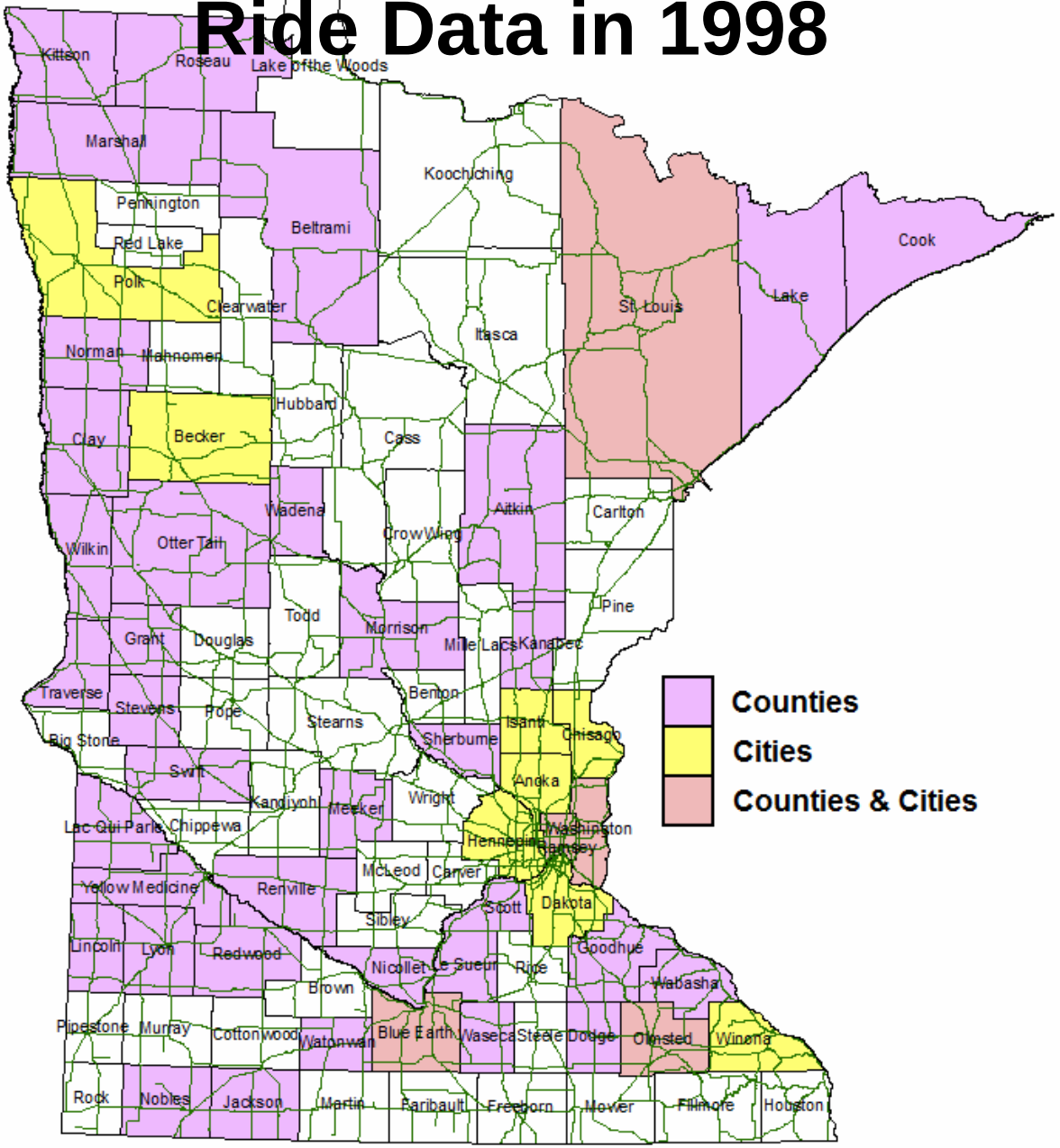
Cities & Counties Collecting Ride Data in 1998



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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