NCHRP Project 9-54
Long-Term Aging of Asphalt Mixtures for Performance Testing and Prediction

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Fall River, MA
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Outline

- NCHRP 09-54 Objectives
- Proposed Long-Term Aging Procedure
- Current Efforts

NCHRP 09-54 Objectives

- **Develop a calibrated and validated procedure to simulate long-term aging of asphalt mixtures for performance testing and prediction**
- Develop a pavement aging model as a function of climate, age, and pavement depth

Development of the Proposed Long-Term Aging Procedure

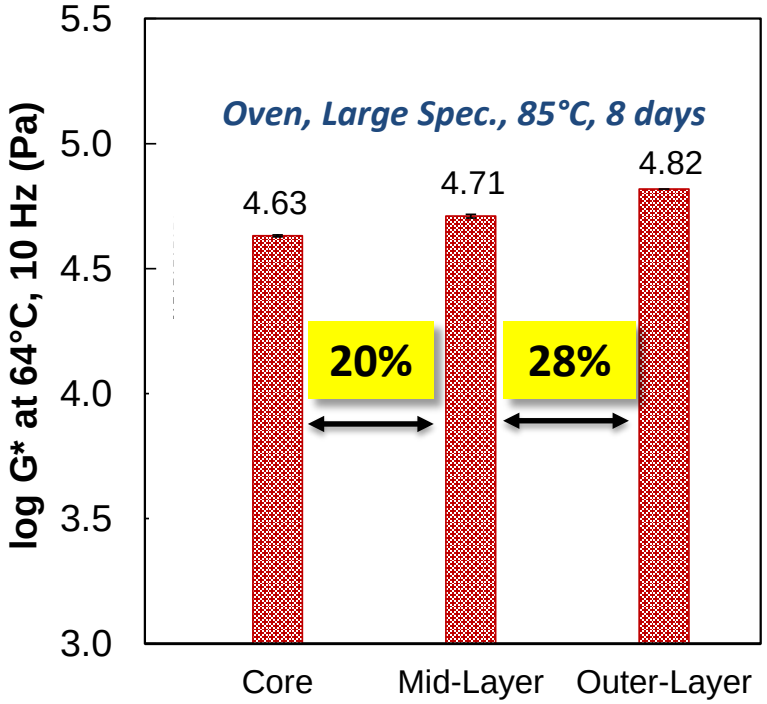
- Selection of the aging method
  - Compacted specimen vs. loose mixture
  - Oven vs. pressure aging vessel
- Selection of the aging temperature
  - 95ºC vs. 135ºC
- Determination of required aging duration
  - Climate, depth, age

Criteria for Selecting the Aging Method

- Specimen integrity
  - Compacted specimen (38-mm and 100-mm)
    - Geometric and air void changes
    - Oxidation gradient
    - Performance
  - Loose mix
    - Compactability
    - Performance
- Efficiency
- Practicality and versatility

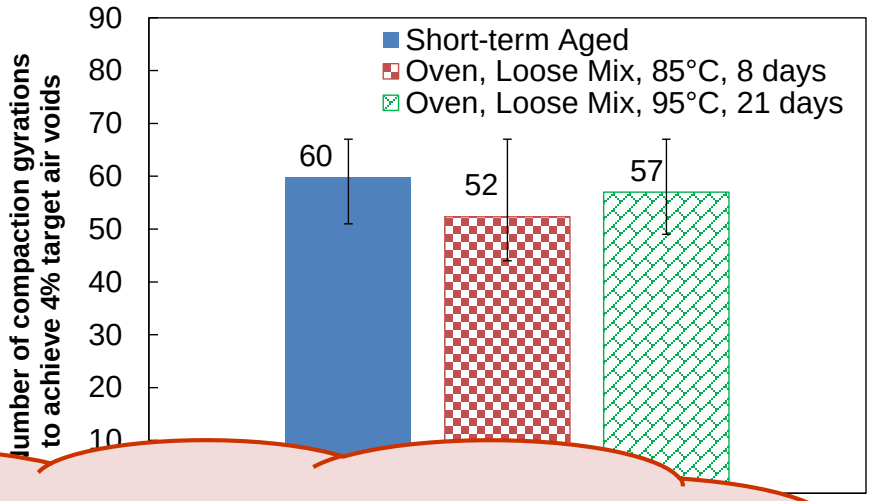
Aging Gradient in Compacted Specimen

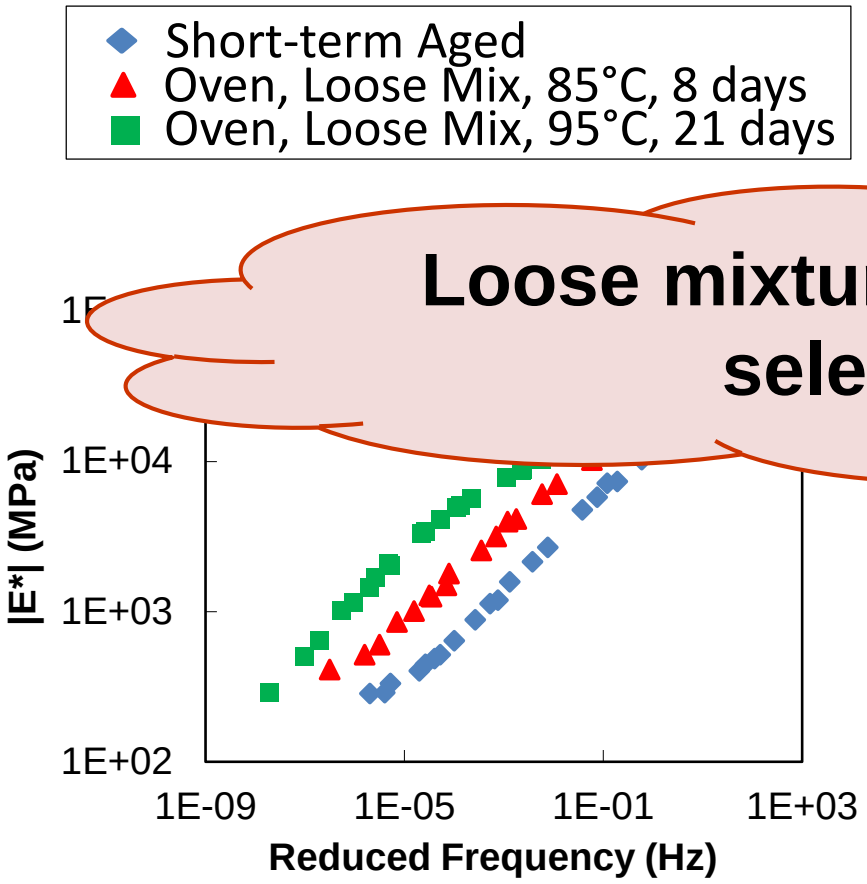
NC 9.5-mm mixture (PG 64-22, no RAP)



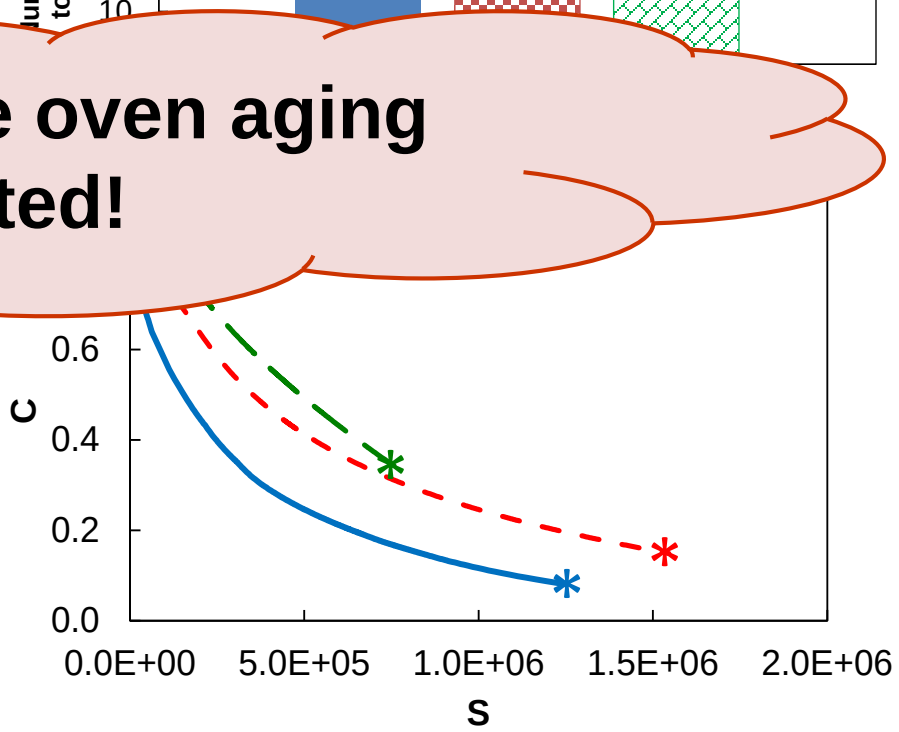
Oven, Small Spec., 85°C, 8 days
≈
Oven, Loose Mix, 85°C, 5.25 days

Compaction of Aged Loose Mixture





Loose mixture oven aging selected!

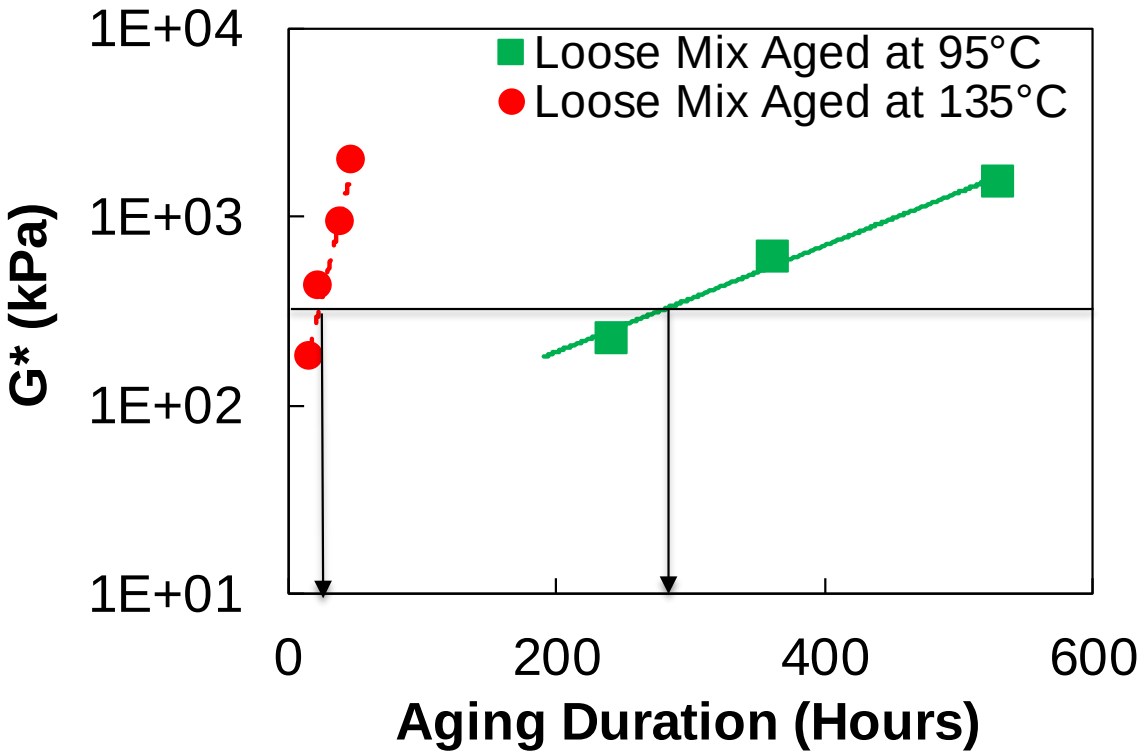


FHWA ALF SBS (PG 70-28, no RAP)

Selection of Laboratory Aging Temperature

- Increasing temperature expedites oxidation
- Aging above 100ºC has raised several concerns
  - Thermal decomposition of sulfoxides
  - Disruption of binder microstructure
  - Binder/Mastic drain-down
- Performance implications of aging above 100ºC unknown

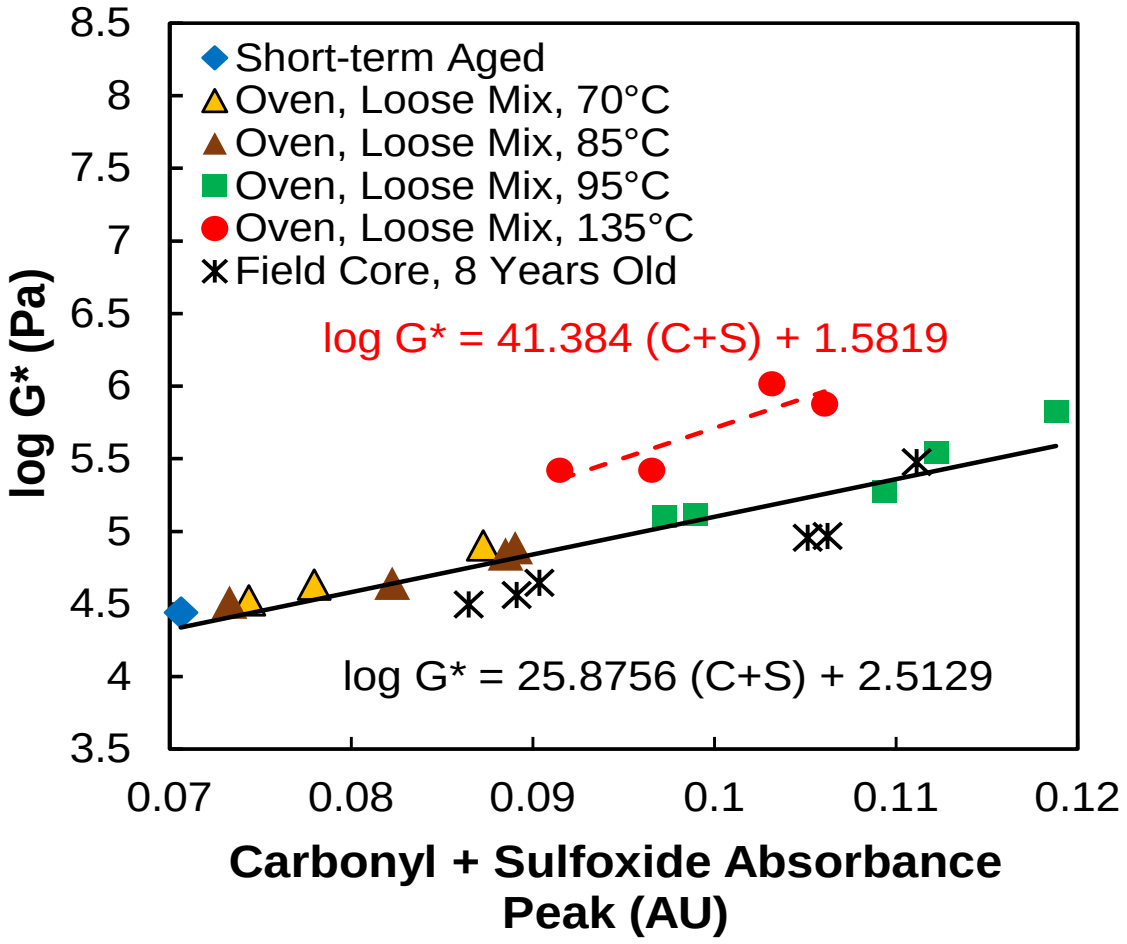
Experimental Approach



- Three mixtures considered: FHWA ALF SBS, SHRP AAD, and SHRP AAG

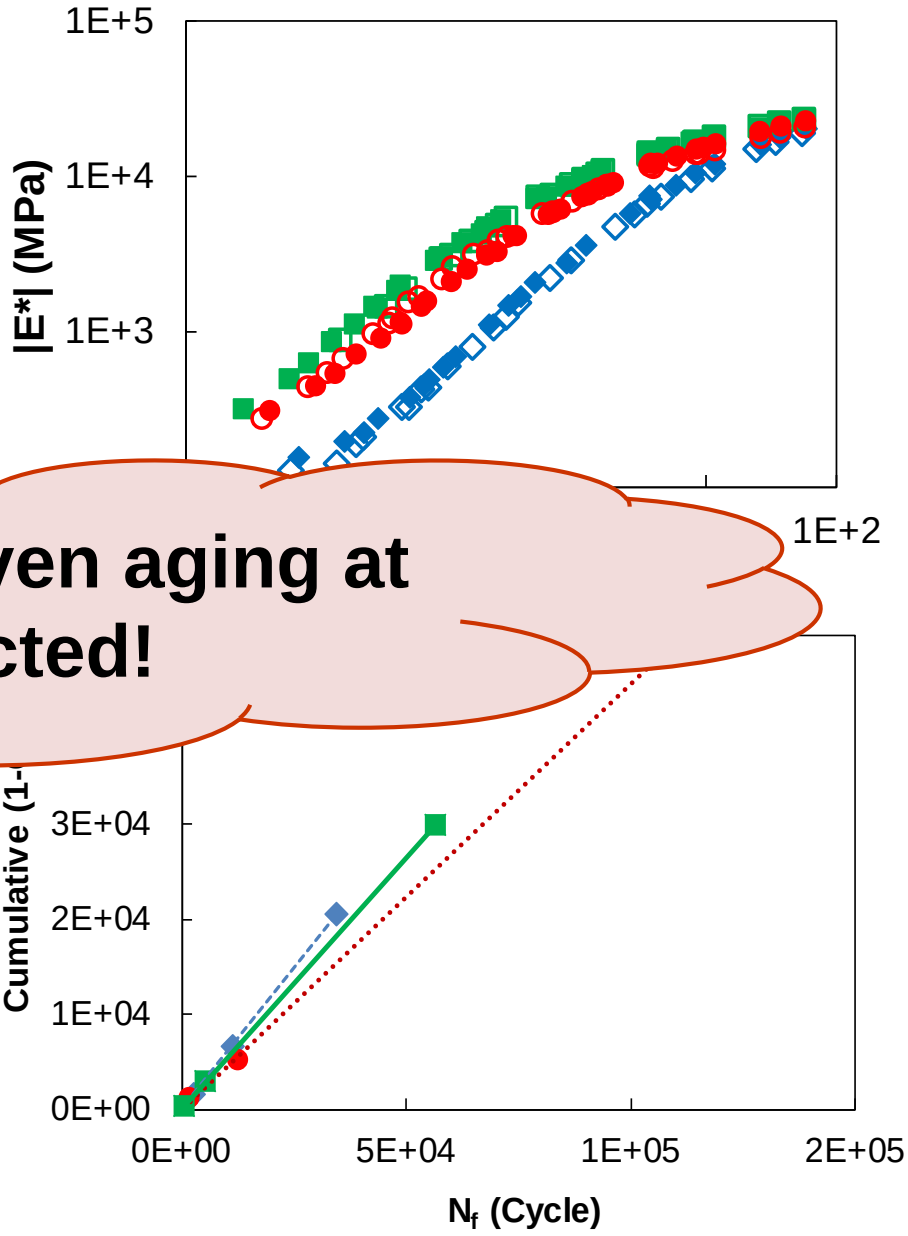
Chemistry vs. Rheology

FHWA ALF-SBS

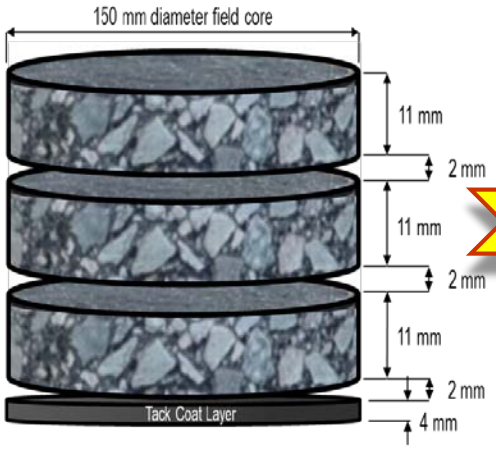


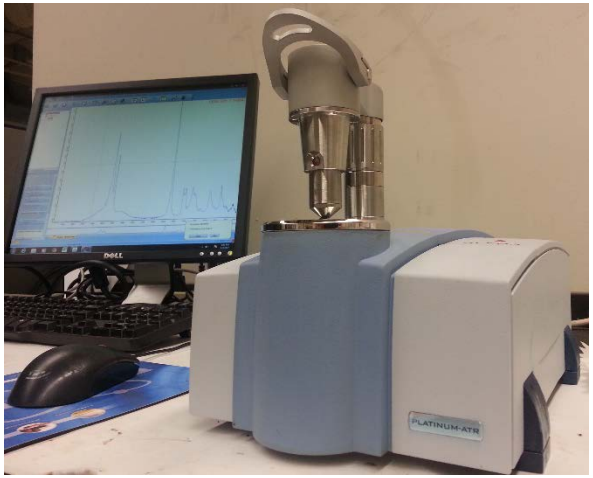
Performance Test Results

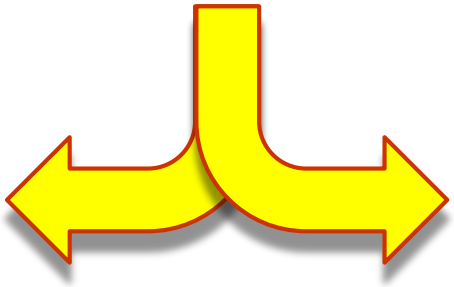
SHRP AAD-1

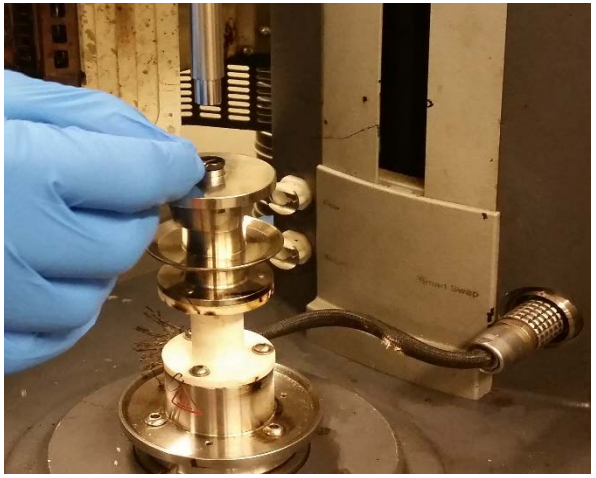


Determination of the Aging Duration

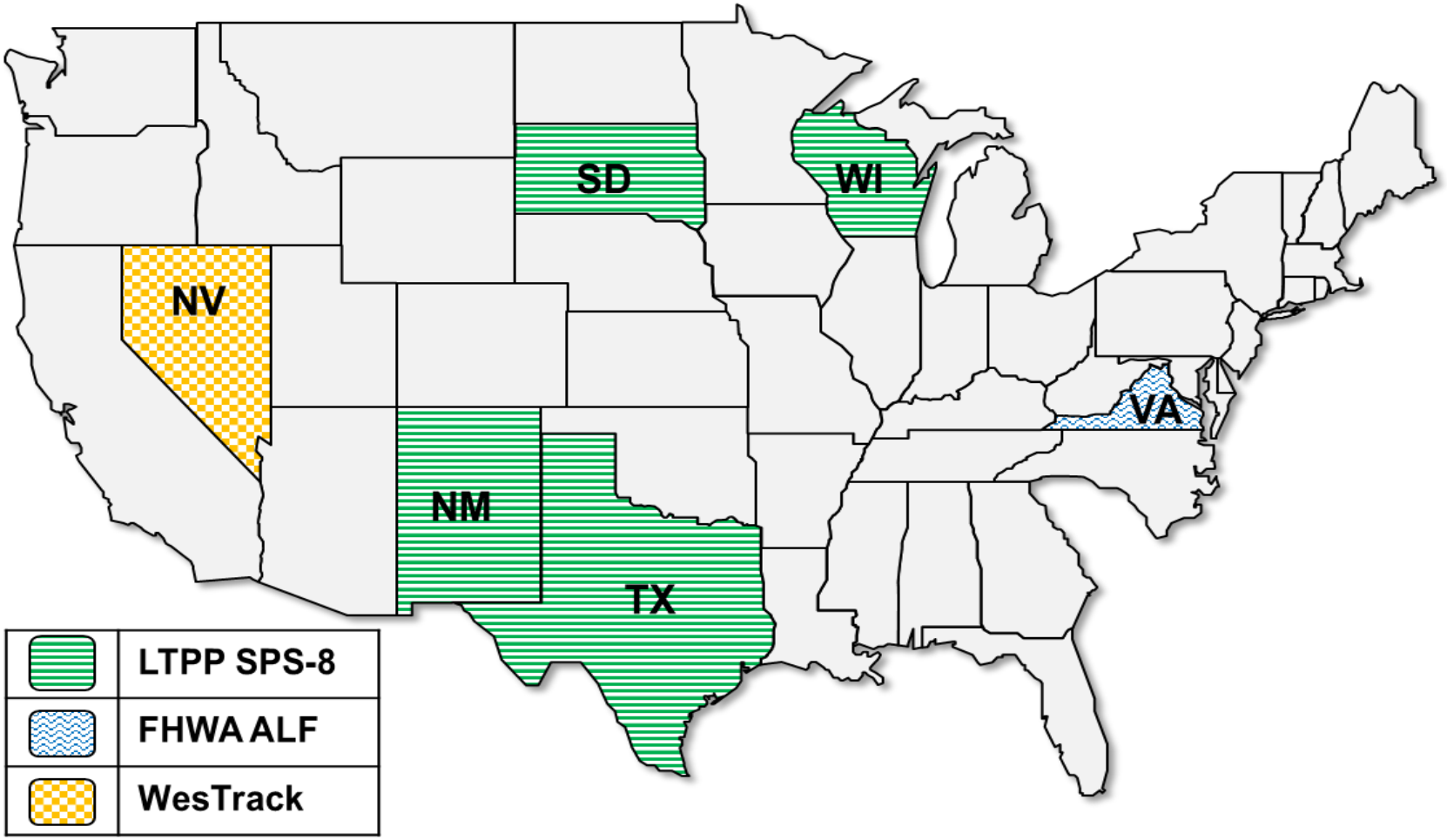








Field Sections



NCHRP 9-54 Kinetics Model

$$\log G^* = \log G_0^* + M\left(1 - \frac{k_c}{k_f}\right)\left(1 - \exp\left(-k_f t\right)\right) + k_c M t$$

where

C

C

M

k_f $= A_f \exp\left(\quad / RT\right)$,

$k_c = A_c \exp\left(-E_{ac}/_{RT}\right)$, and

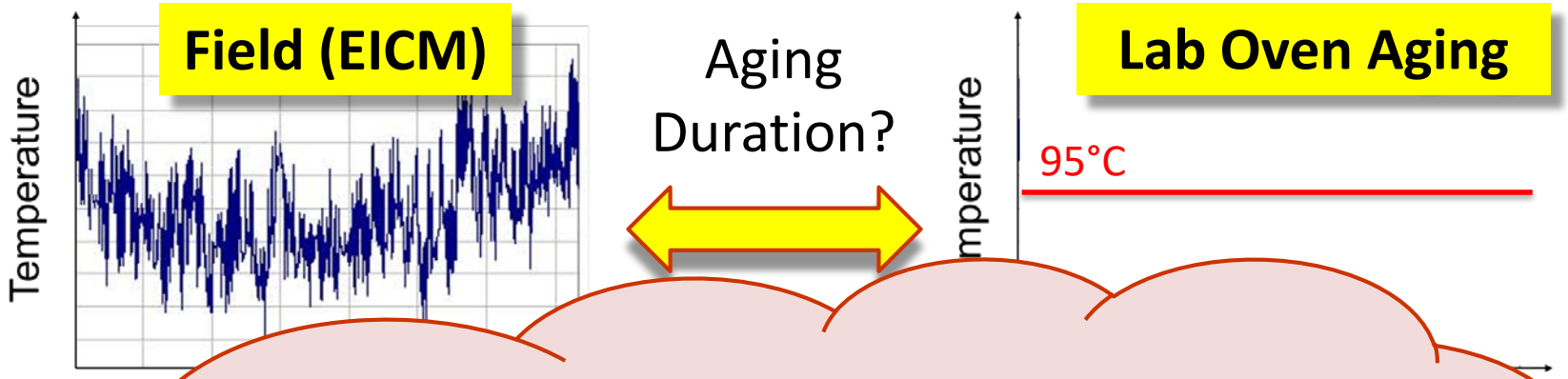
T = temperature in Kelvin.

G_0^*, M - Material dependent parameters

A_f, A_c, E_{af}, E_{ac} - Universal constants

Calibrated and validated!

Required Duration to Match Field Aging



Required aging duration to match field aging is independent of binder source/type (i.e., STA G* and M value)

$$\log G^*_{Field} = \log G^*_{Lab}$$

$$[(1 - {}^{k_c}/_{k_f})(1 - \exp(-k_f t)) + k_c t]_{Field} = [(1 - {}^{k_c}/_{k_f})(1 - \exp(-k_f t)) + k_c t]_{Lab}$$

Climatic Aging Index (CAI)

$$CAI = \sum_{i=1}^{24} \left(D \times A \times \exp\left({}^{-E_a}/_{RT_i} \right) /24 \right) = t_{oven}$$

$$D = \begin{cases} 3.4311\, d^{-0.683} & \text{for } 6\, mm \leq d \leq 35\, mm \\ 0.3026 & \text{for } d > 35\, mm \end{cases}$$

where

D = depth correction factor,

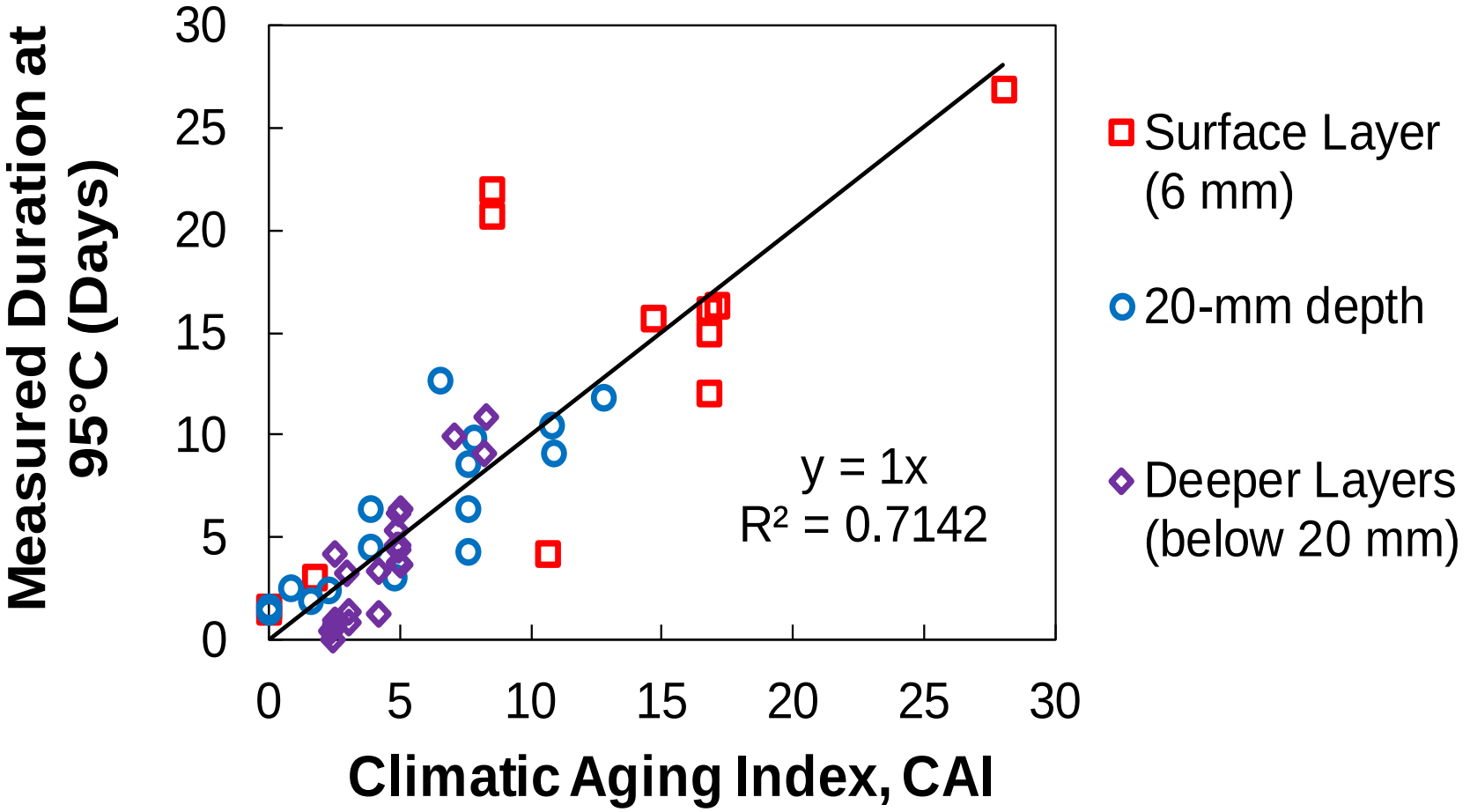
A, E_a = fitting parameters,

R = universal gas constant,

T = pavement temperature (Kelvin), and

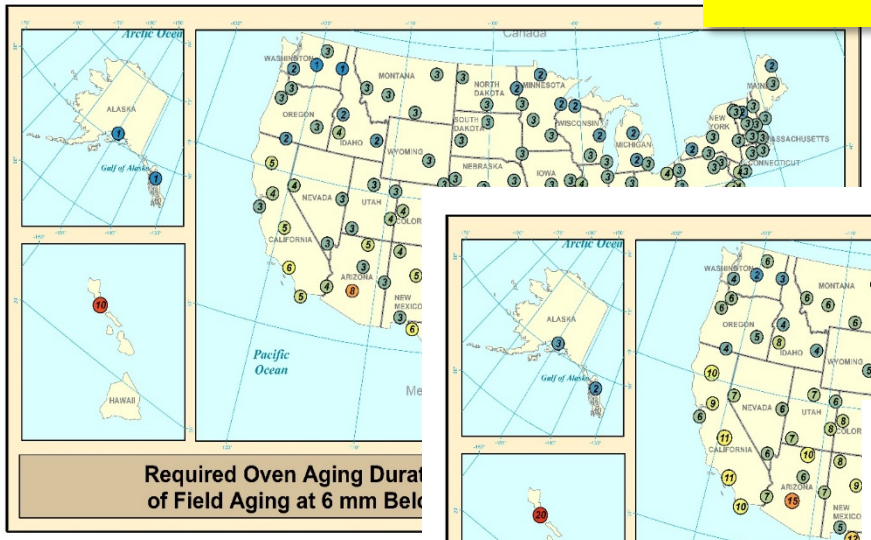
d = depth of interest (mm).

Climatic Aging Index (CAI)

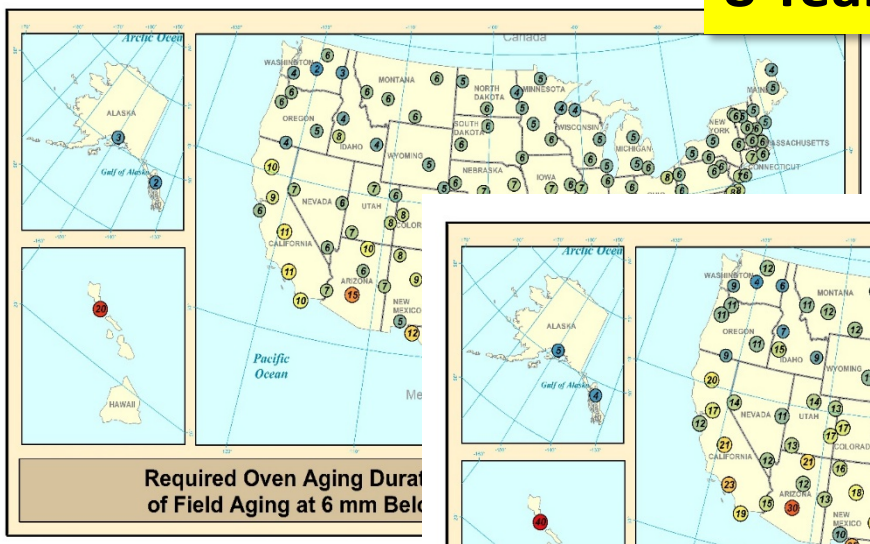


Aging Duration Maps for 6 mm Depth

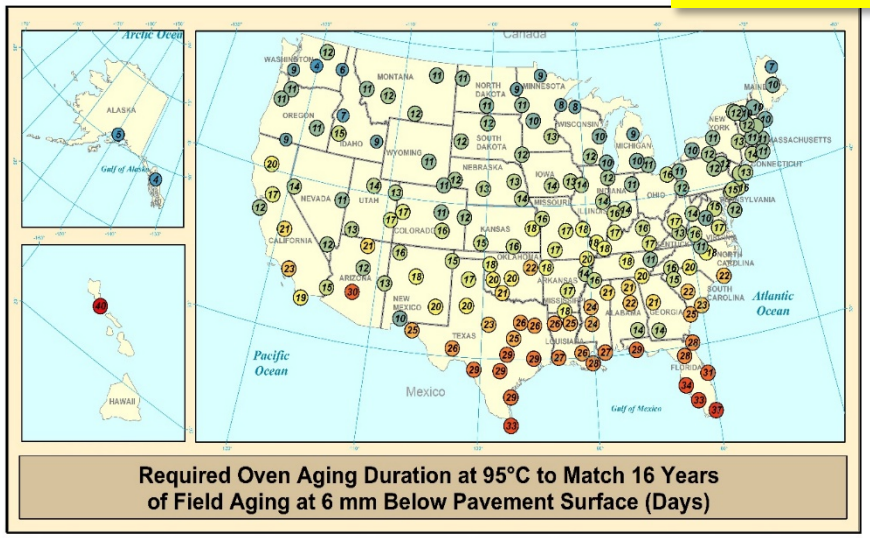
4 Years



8 Years

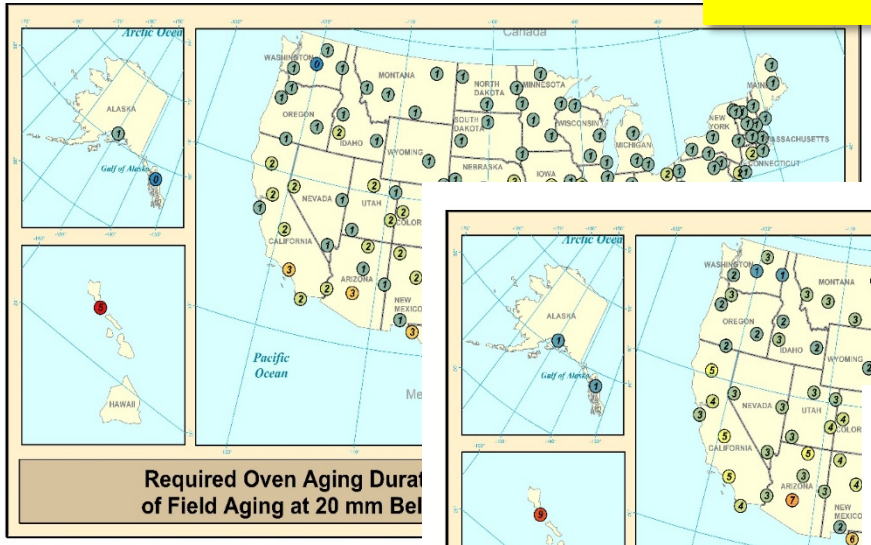


16 Years

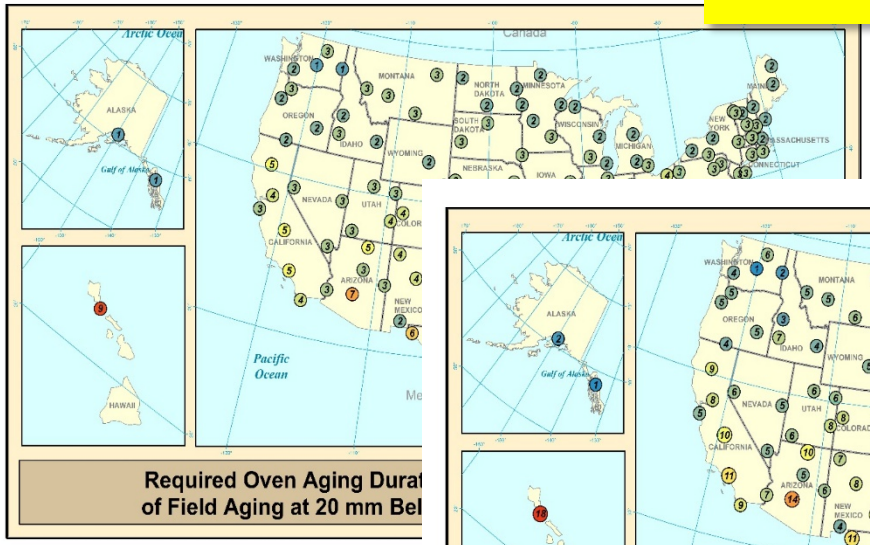


Aging Duration Maps for 20 mm Depth

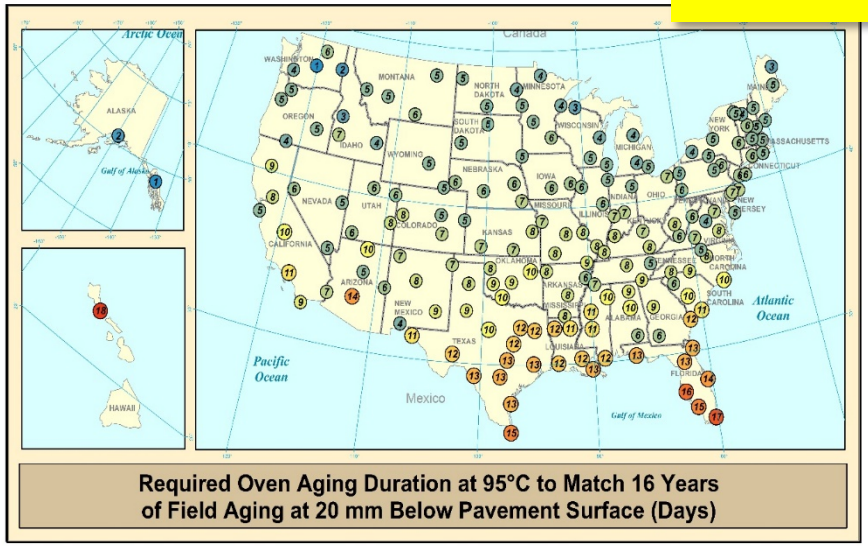
4 Years



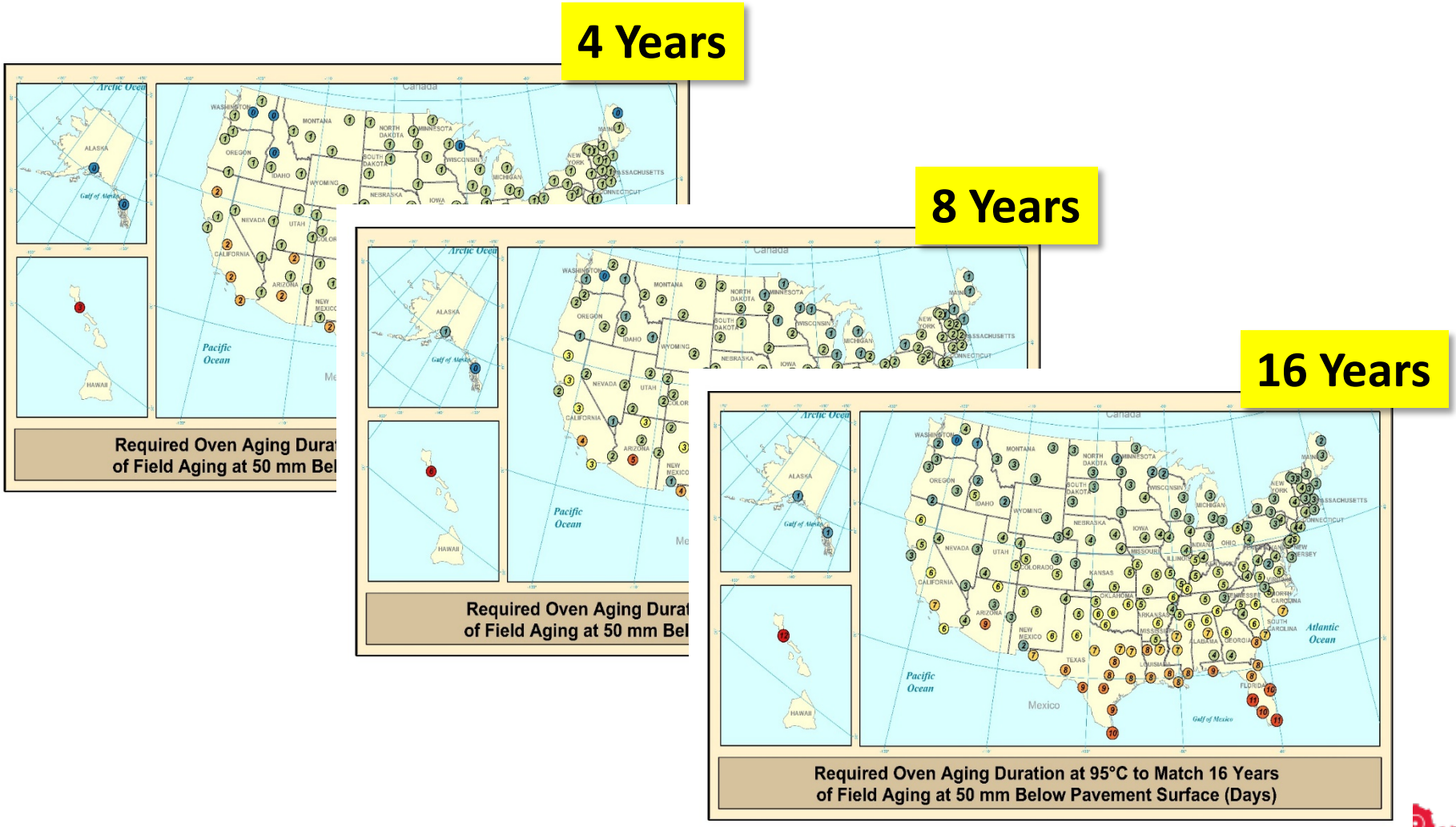
8 Years



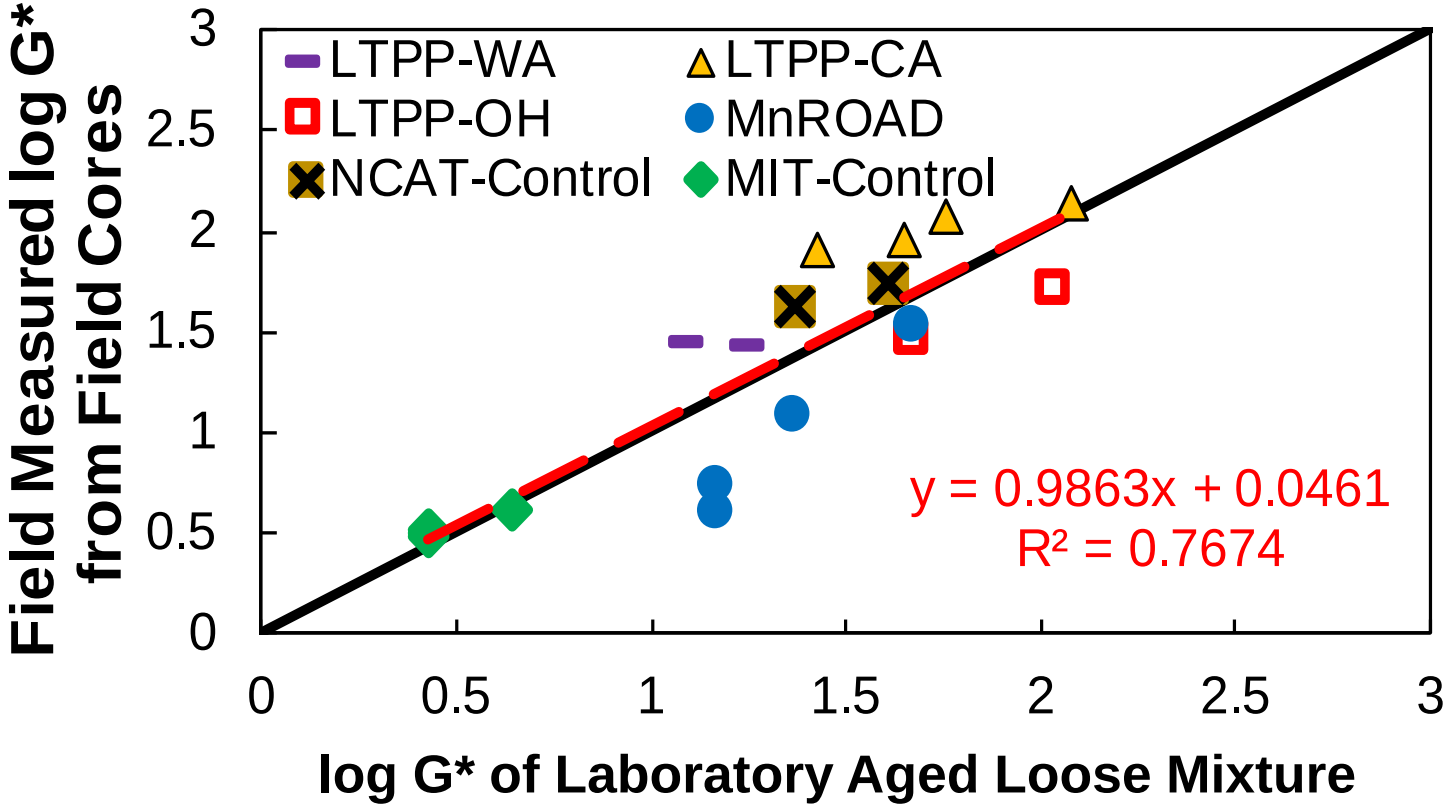
16 Years



Aging Duration Maps for 50 mm Depth



Validation of the Developed Aging Procedure



Proposed AASHTO Standard

Standard Method of Test for

Long-Term Conditioning of Asphalt Mixture for Mixture Performance Testing

AASHTO Designation: TP ###-##

AASHTO
THE VOICE OF TRANSPORTATION

1. SCOPE

1.1. This practice describes procedures for long-term conditioning of uncompacted asphalt mixture for mixture mechanical property testing to simulate the aging that occurs over the service life of a pavement. The long-term conditioning for mixture mechanical property testing procedure is preceded by the procedure for short-term conditioning for mixture mechanical property testing.

Summary

- Oven aging of loose mixture at 95ºC recommended
- A climatic aging index (CAI) developed by simplifying the kinetics model prescribes the laboratory aging duration to match field aging as a function of hourly pavement temperature history and depth
- Draft AASHTO standard developed for long-term aging of asphalt mixtures for performance testing

Current Efforts

- Refinement of the aging duration maps
- Finalization of pavement aging model
- Investigation of effects of binder aging on asphalt mixture cracking performance

Questions?