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

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Ames, IA
May 1, 2017

Outline

- NCHRP 09-54 objectives
- Proposed Long-Term Aging Method
- Kinetics Modeling
- Aging Durations Based on Climatic Data

NCHRP 09-54 Objectives

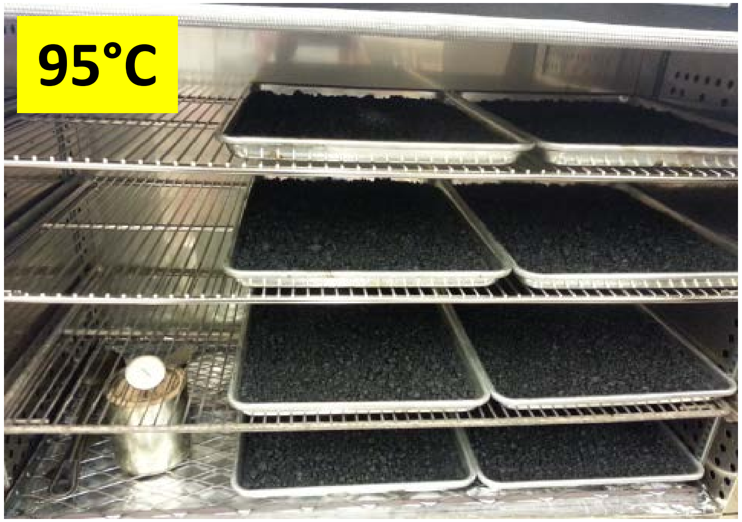
- Develop a calibrated and validated procedure to simulate long-term aging of asphalt mixtures for performance testing and prediction.
- Develop an aging model that is more accurate than GAS model and less cumbersome than the Transport model (developed by Texas A&M).
- Develop calibration functions by investigating the differences in mechanical properties as functions of traffic, climate, and moisture.

Aging Factors Investigated

- Pressure vs. Oven
- Compacted specimen vs. Loose mix
- 95°C vs. 135°C

Proposed Long-Term Aging Method

- **Oven** aging of **loose mix** at **95°C** was found to be the most promising method for long-term aging of asphalt mixture based on the following criteria:
  - Specimen integrity (Compactability)
  - Uniformity of oxidation
  - Efficiency
  - Practicality and versatility
  - Simulation of physicochemical changes in field aging



Kinetics Modeling

Verification of Existing Kinetics Models Using Rheological AIP (log G*) and Laboratory Aged Loose Mix Data

Kinetics Modeling

Herrington _ New Zealand

$$P = M\left(1 - \exp\left(-k_f t\right)\right) + k_c t$$

Charles Glover _ Texas A&M

$$\text{CA} = CA_{tank} + M\left(1 - \exp\left(-k_f t\right)\right) + k_c t$$

Petersen and Glaser _ WRI

$$(C + S) = (C + S)_0 + M\left(1 - \frac{k_c}{k_f}\right)\left(1 - \exp\left(-k_f t\right)\right) + k_c M t$$

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

where

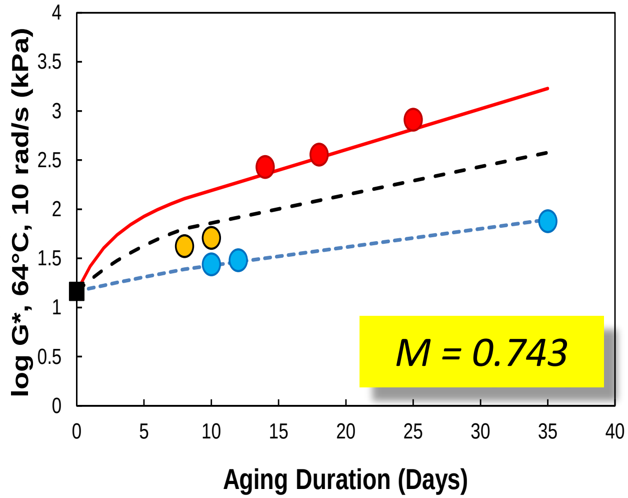
$$k_f = A_f \exp\left({}^{-E_{af}}/_{RT}\right) \qquad k_c = A_c \exp\left({}^{-E_{ac}}/_{RT}\right)$$

Kinetics Modeling

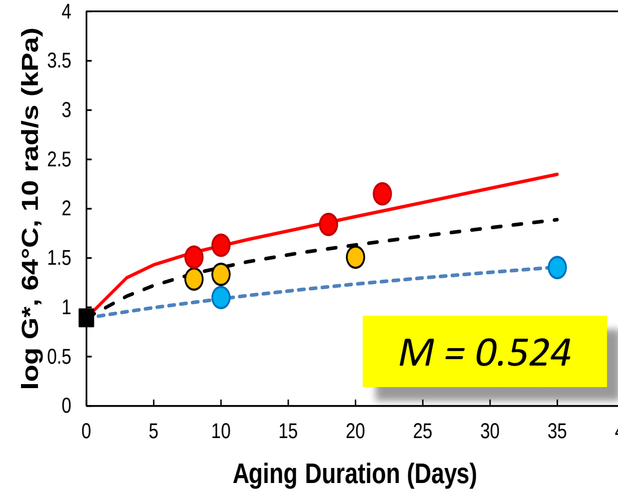
- 95°C Measured
- 85°C Measured
- 70°C Measured
- 95°C Predicted
- 85°C Predicted
- 70°C Predicted
- STA

Single Binder Dependent Variable (M)

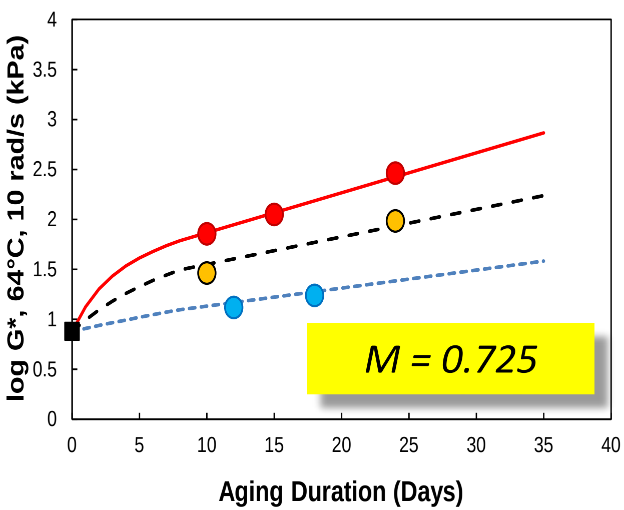
ALF-Control



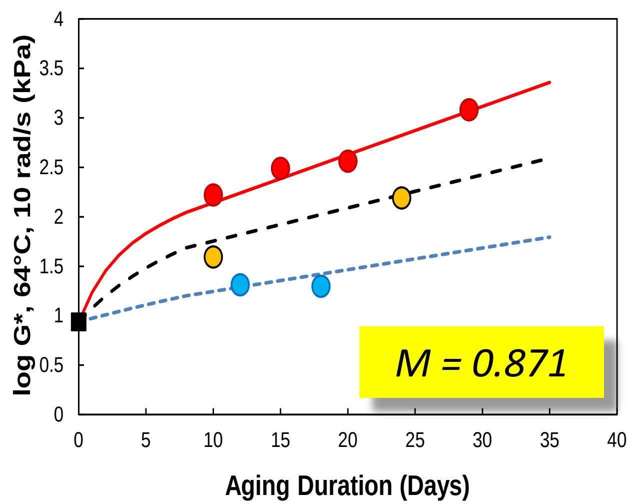
ALF-SBS



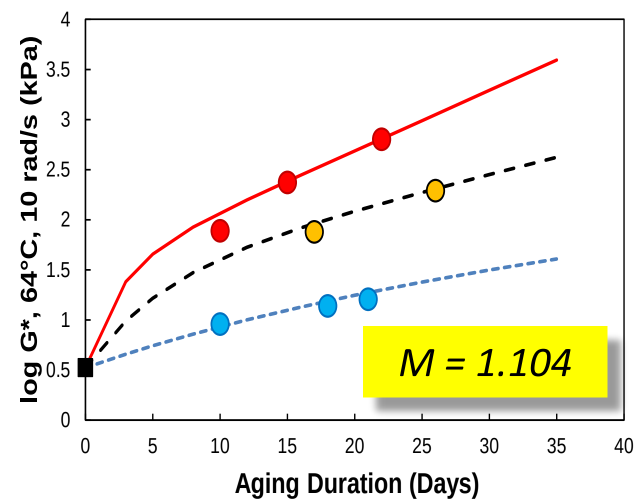
WesTrack-Coarse



WesTrack-Fine



SHRP-AAD-1

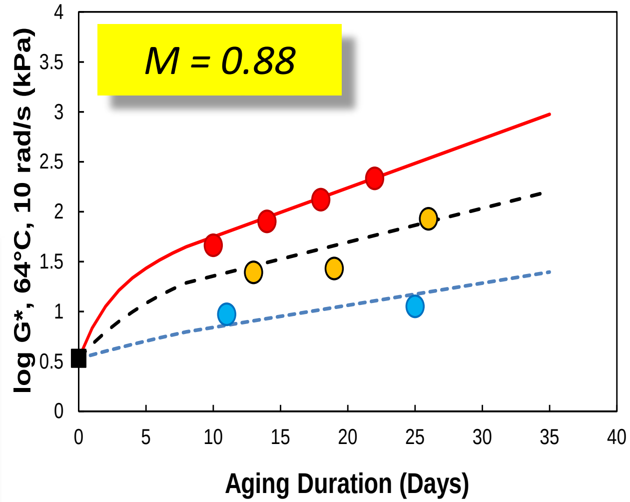


Kinetics Model Verification

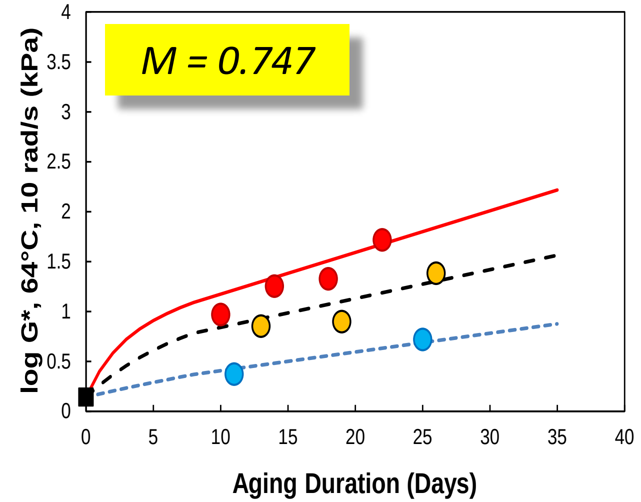
- 95°C Measured
- 85°C Measured
- 70°C Measured
- 95°C Predicted
- 85°C Predicted
- 70°C Predicted
- STA

Single Binder Dependent Variable (M)

LTPP-TX



LTPP-SD



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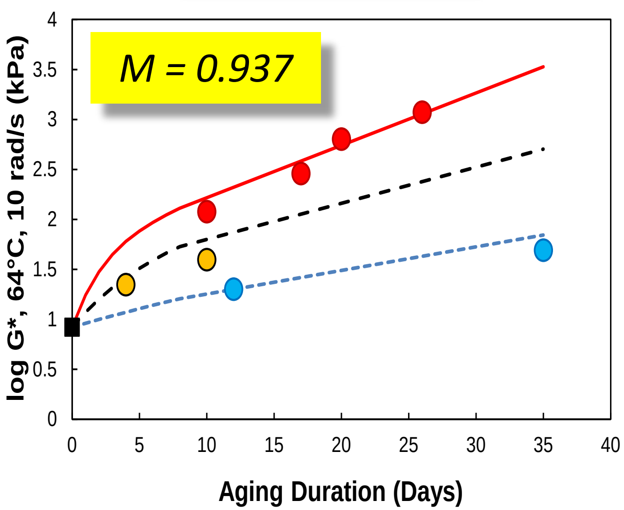
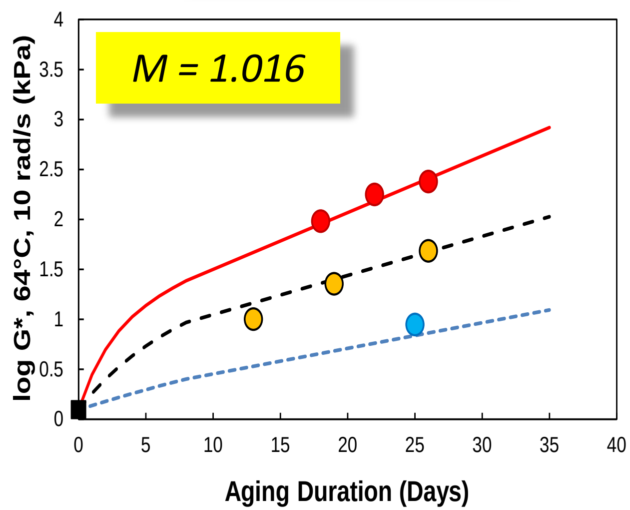
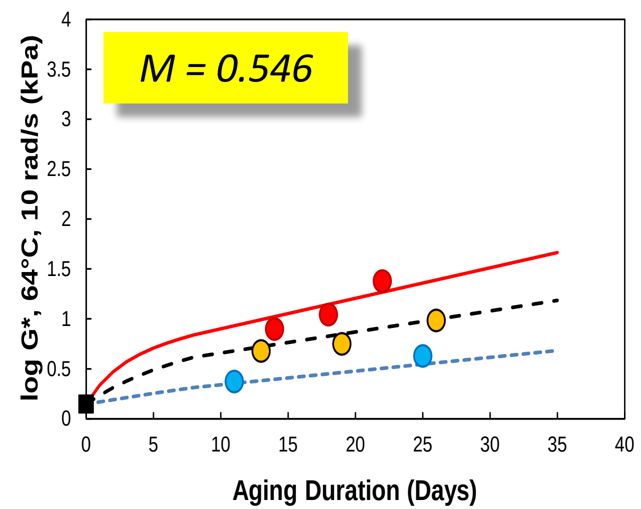


LTPP-WI

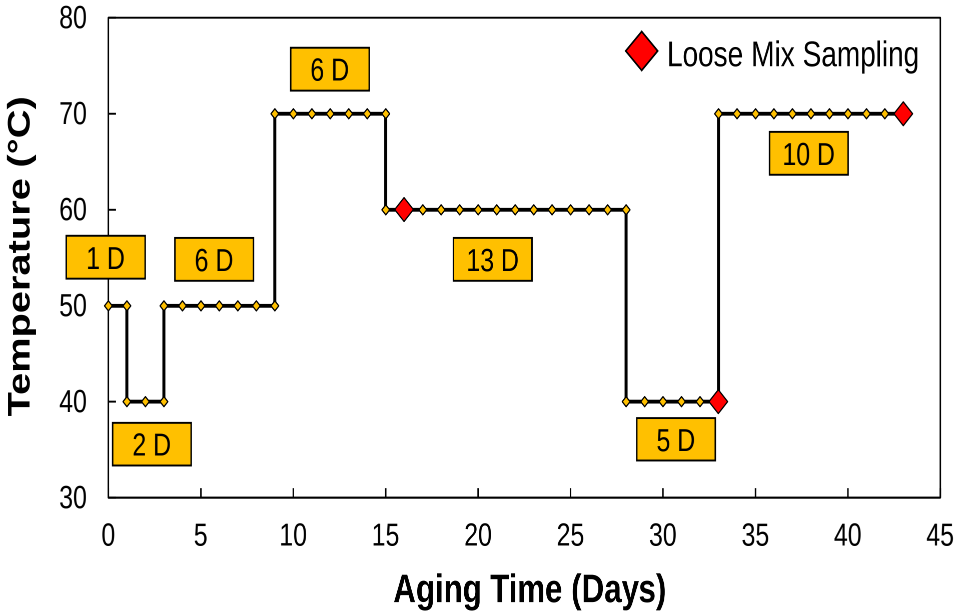


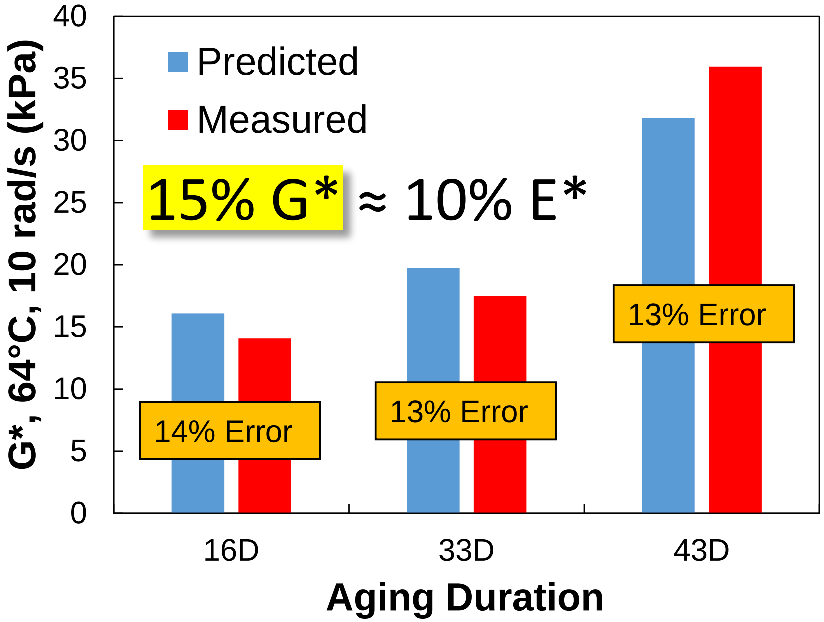
LTPP-NM



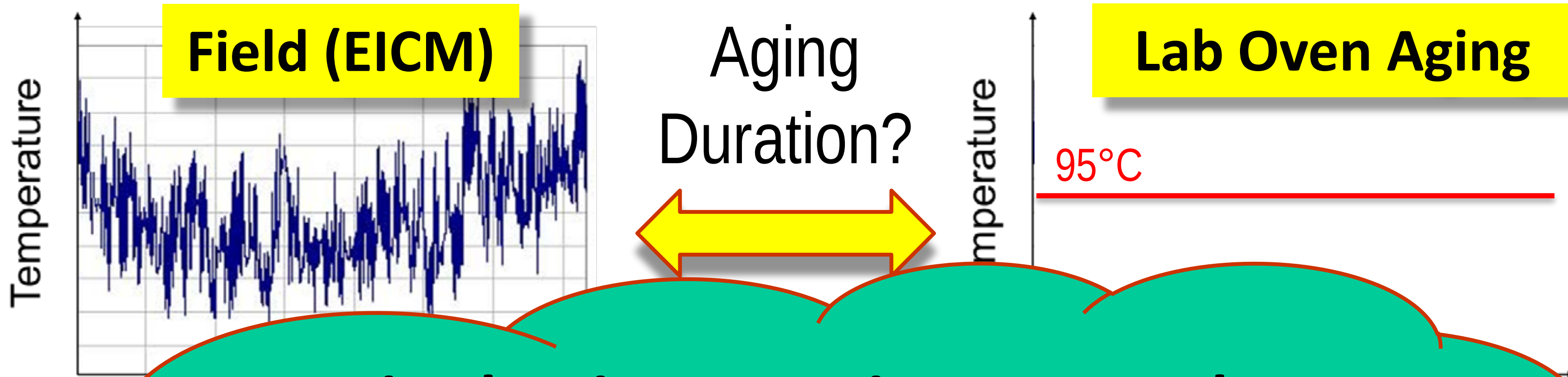
Verification Using Non-Isothermal History

- WesTrack Fine 1995





Kinetics Modeling to Find 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)

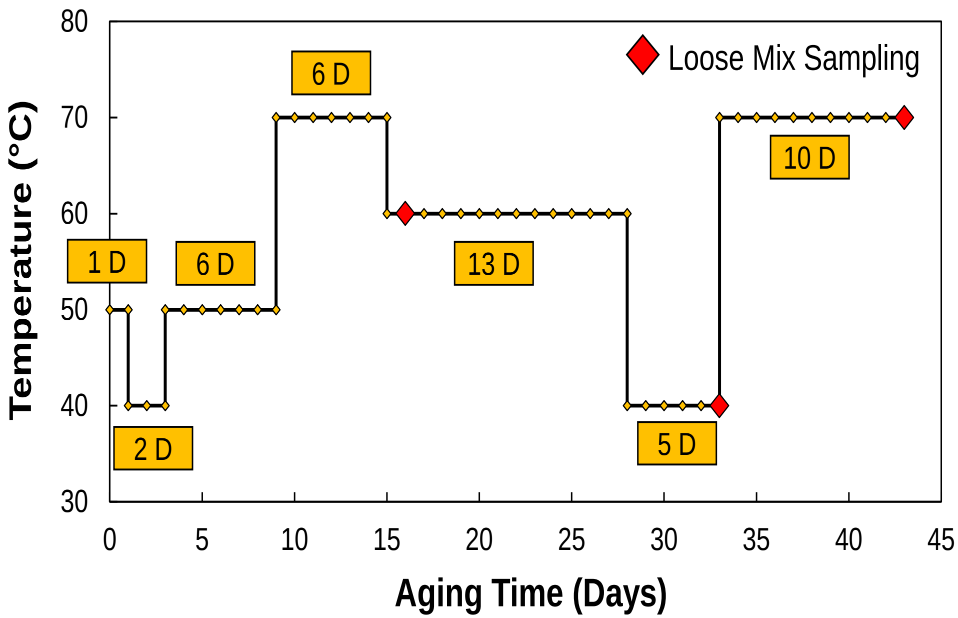
log

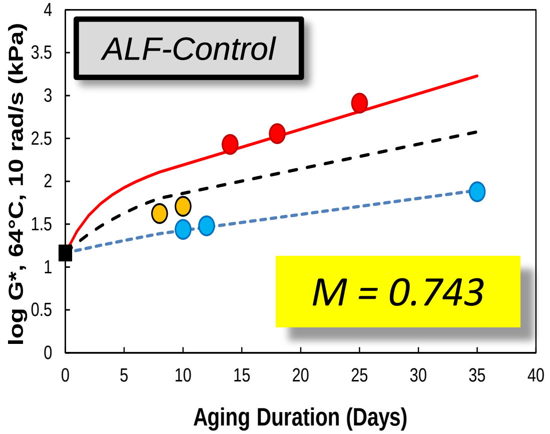
$\log G_{Lab}{}^{*} = \log G_o$ … $[(1$ … $p(-k_f t)) + k_c t]_{Lab}$

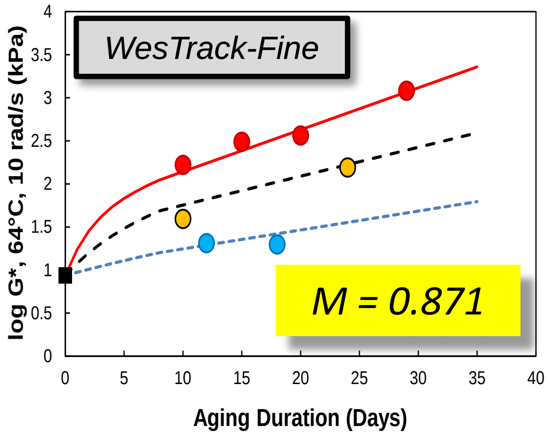
$$[(1-{}^{k_c}/_{k_f})(1-\exp(-k_f t))+k_c t]_{Field} = [(1-{}^{k_c}/_{k_f})(1-\exp(-k_f t))+k_c t]_{Lab}$$

Non-Isothermal Aging Verification

- Non-Isothermal Laboratory Aging Trial
  - FHWA ALF Control
  - WesTrack Fine 1995







Non-Isothermal Aging Verification

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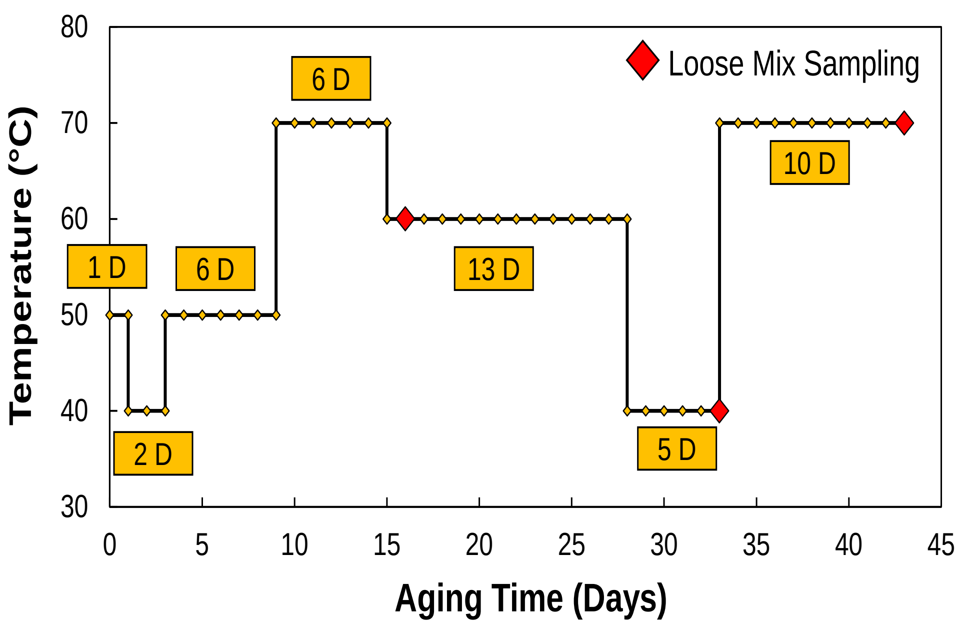
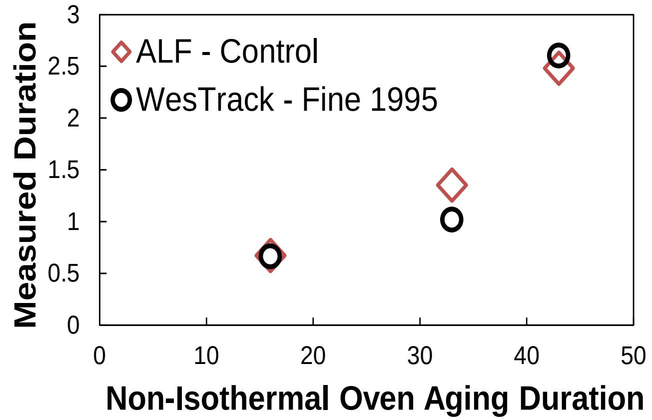
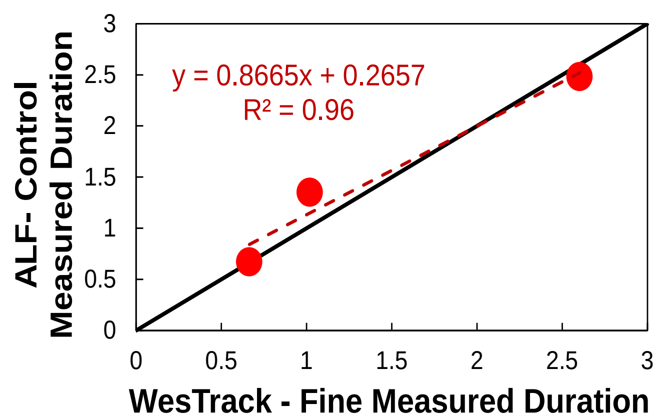
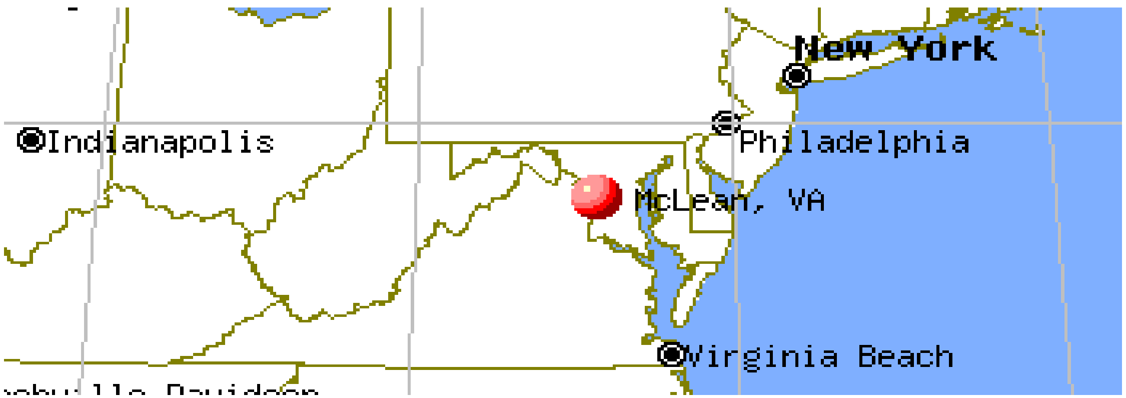




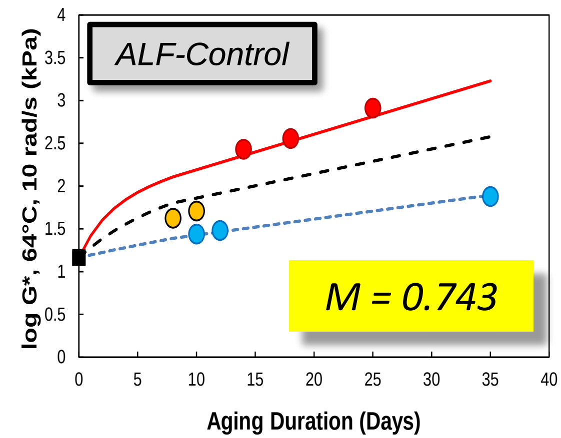


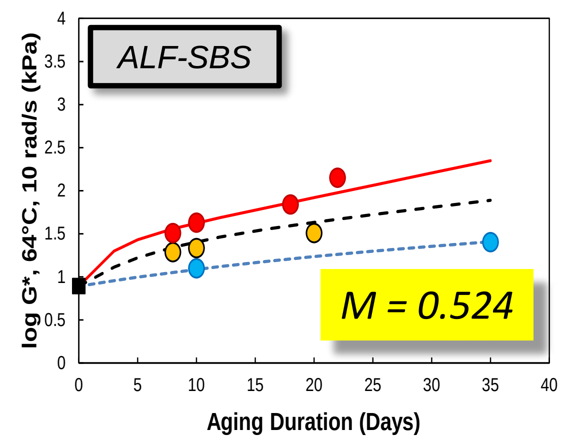
Verification from Field Cores

- Field Cores from:
  - FHWA ALF Control
  - FHWA ALF SBS-LG Modified



Field (19 mm depth)	Required Durations
ALF-Control	7.7 days
ALF-SBS	8 days



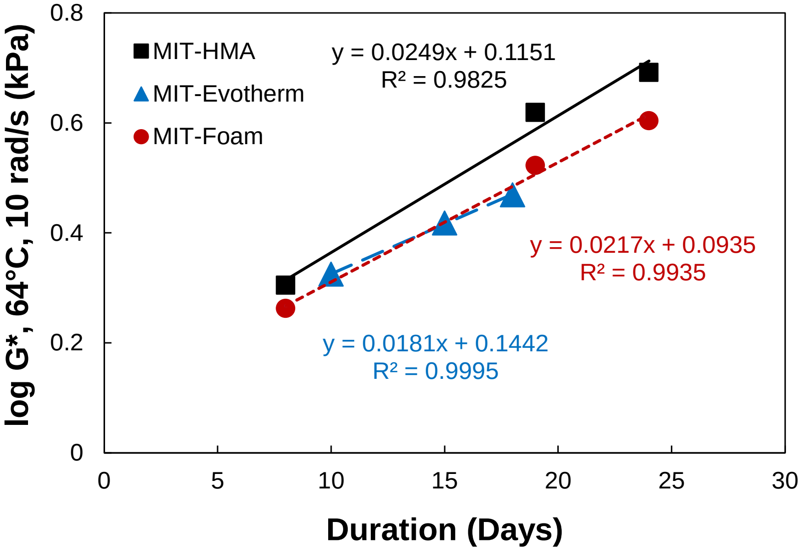


Verification from WMA vs. HMA

Manitoba Sections – 4 Years Old

- Matching field aging levels in the laboratory

Field Section	Depth	Required Durations at 85°C
MIT-Control HMA	19 mm	16.5 days
MIT-WMA Evotherm	19 mm	16.1 days

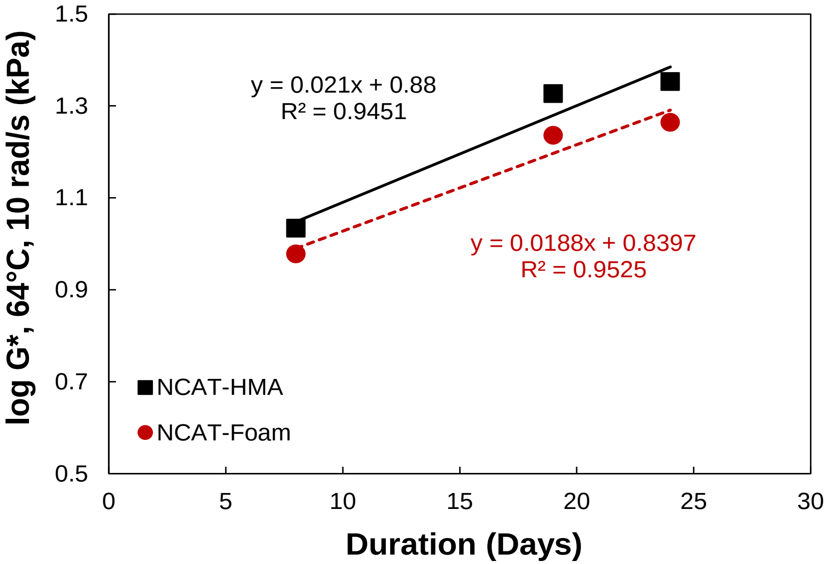


Verification from WMA vs. HMA

NACT Sections – 4 Years Old

- Matching field aging levels in the laboratory

Field Section	Depth	Required Durations at 85°C
NCAT-Control HMA	19 mm	35.6 days
NCAT-WMA Foam	19 mm	31.3 days



Aging Durations Based on Climatic Data

Matching 4, 8, and 16 Years of Field Aging

Climatic Aging Index

- Climatic Aging Index (CAI)

$$\text{CAI} = \sum \left(A \times \exp\left({}^{-E_a}/_{RT}\right)\right)/24)$$

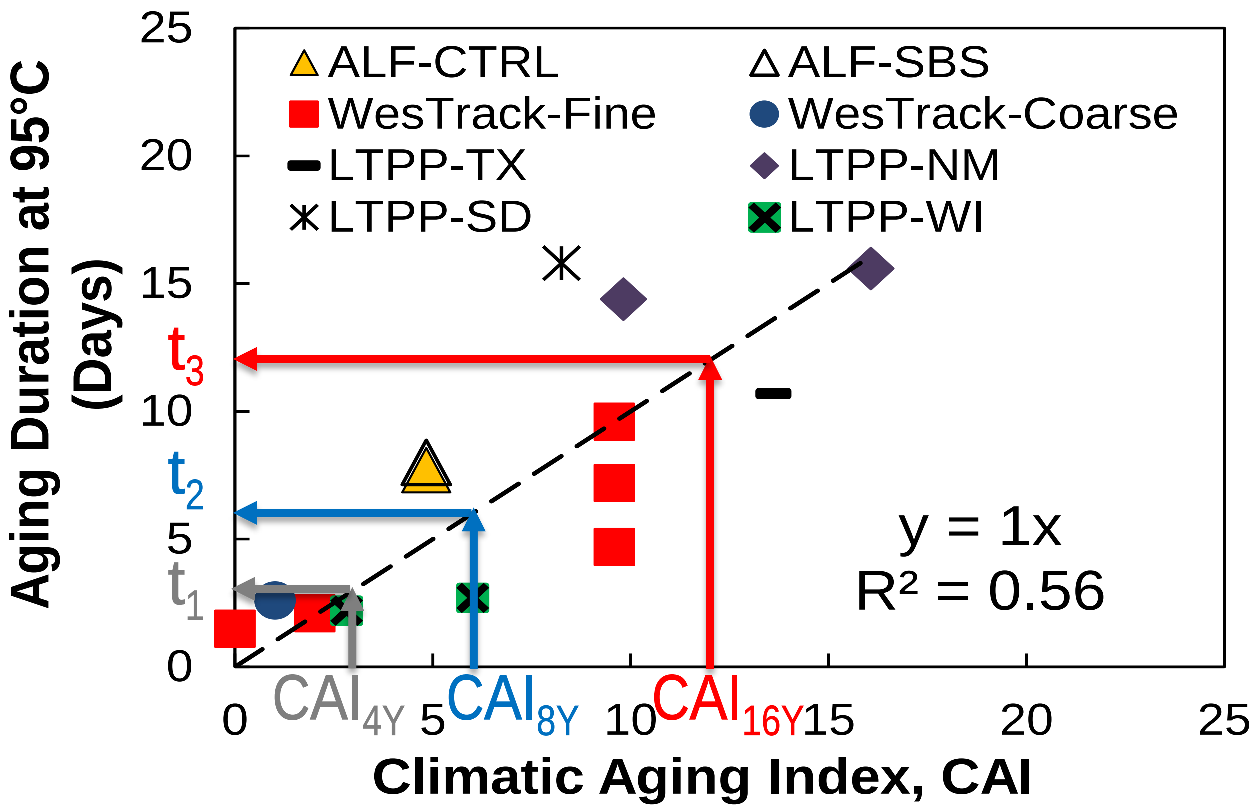
where

A, E_a = Fitting Parameters

R= Universal Gas Constant

T= Air Temperature in Kelvin

Aging Durations Based on Climatic Data



Questions?