Validation of Loose Mix Aging Procedures for Cracking Resistance Evaluation in Balanced Mix Design

Year 1 Update Meeting

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Research Team

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Research Objective

Validate candidate loose mix aging procedures* with a wide range of field projects with various mixture components, pavement ages, and climatic conditions

*Note: * for long-term aging of asphalt mixtures for performance testing in BMD*

Phase I

- Critically review existing aging studies
- Synthesize aging data and identify knowledge gaps
- Develop Phase II work plan

Phase II (future)

- Execute Phase II work plan to address knowledge gaps and provide implementation guidance

Literature Review Report

- Over 60 references
- Report structure (3 sections)

1. Development and preliminary field validation of loose mix aging procedures

   Q: How do the existing procedures correlate to field aging?

2. Impact of loose mix aging on asphalt binder and mixture properties

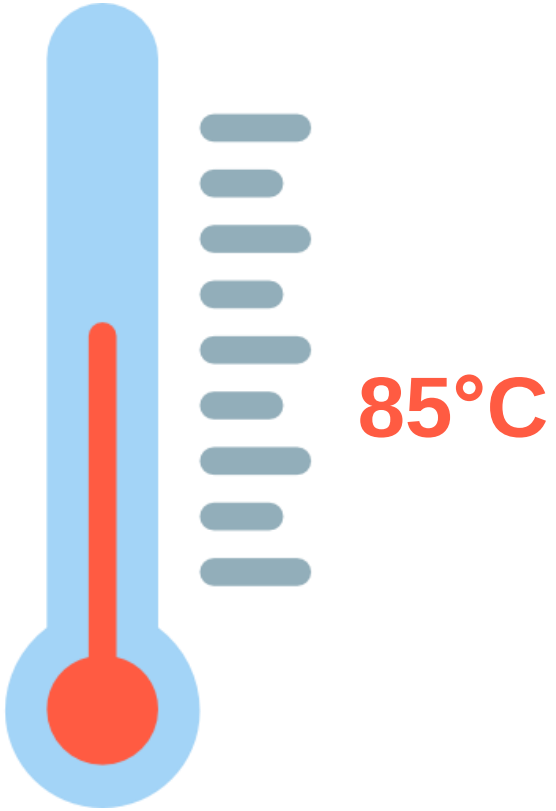
   Q: Which tests (and parameters) are sensitive to loose mix aging and thus, can be used for lab-to-field aging validation in Phase II?

3. Effects of silo storage, mix hauling, mix reheating, specimen storage, and asphalt weathering on asphalt binder and mixture properties

   Q: How do these factors affect asphalt aging?

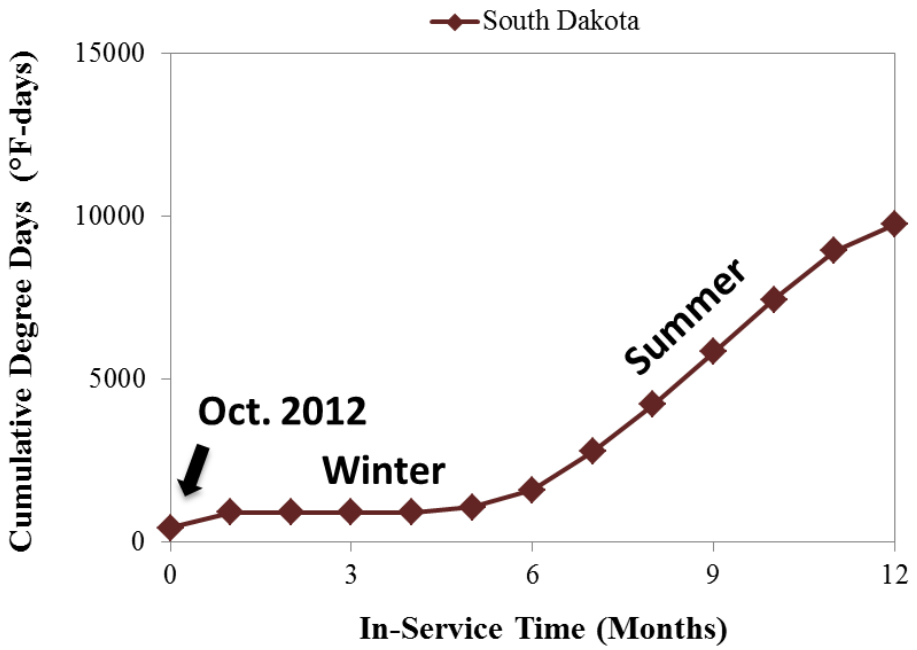
Loose Mix Aging for 5 Days at 85°C

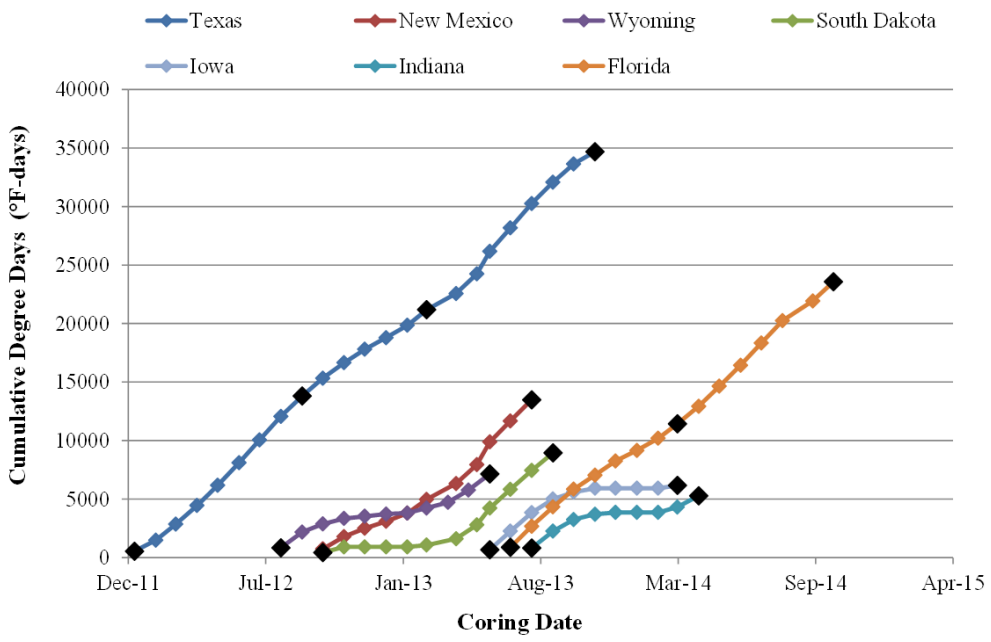
- Developed in NCHRP 09-52A at TTI
- Expected to simulate 114,000 cumulative degree days (CDD) of field aging for surface mixtures



What is CDD?

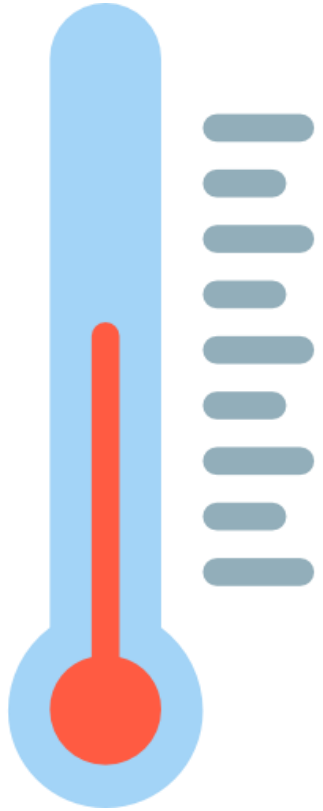
- Defined as sum of the daily high temperature above freezing for all the days from time of construction to the time of core sampling
- A simple climate index to “normalize” the field aging of projects with different construction seasons and geographic locations





Loose Mix Aging for 5 Days at 85°C

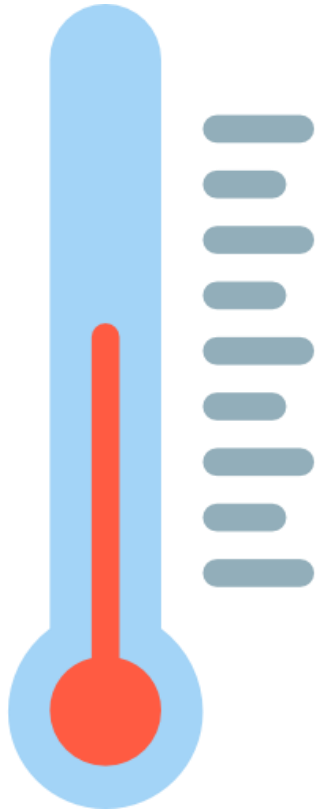
- Developed in NCHRP 09-52A at TTI
- Expected to simulate 114,000 cumulative degree days (CDD) of field aging for surface mixtures
  - 7 to 10 years in warmer climates
  - 12 to 14 years in cooler climates
- Correlation developed based on limited Mr stiffness results (4 mixtures)



85°C

Loose Mix Aging at 95°C

- Developed in NCHRP 09-54 at NCSU
- A series of aging maps for field correlation
  - Pavement location
  - Field aging time
  - Pavement depth
- Aging time varies from 0.1 to 32 days
- Correlation developed based on |G*| kinetics model & validated with 30 mixtures
  - Further validation needed for RAP mixtures



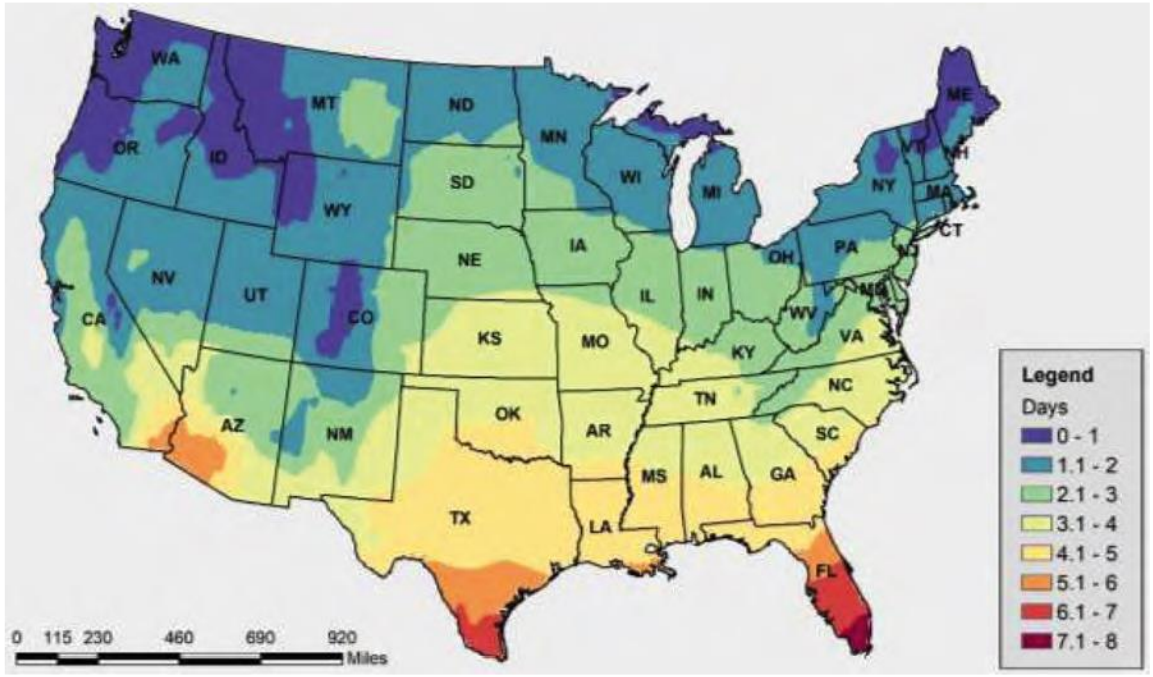
95°C

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

NCHRP 09-54 95°C Loose Mix Aging Maps

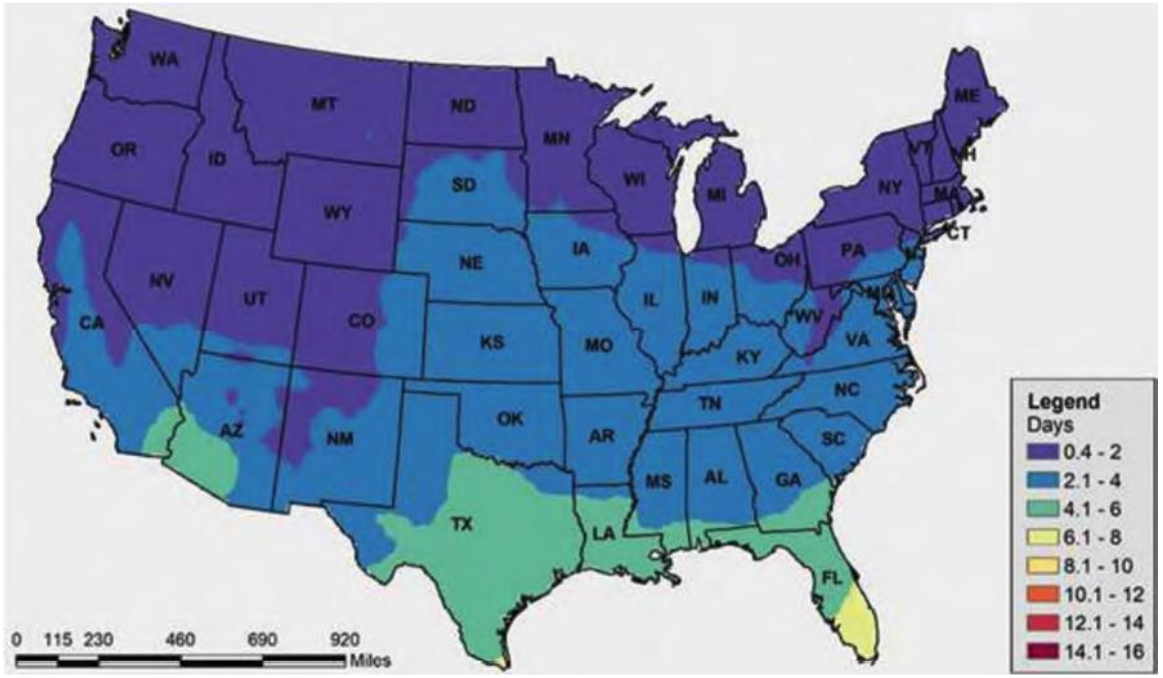
4 Years of Field Aging

6 mm below Pavement Surface



8 Years of Field Aging

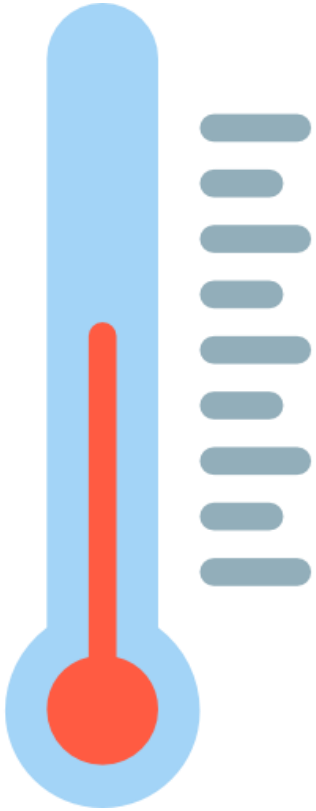
30 mm below Pavement Surface



(Kim et al., 2021)

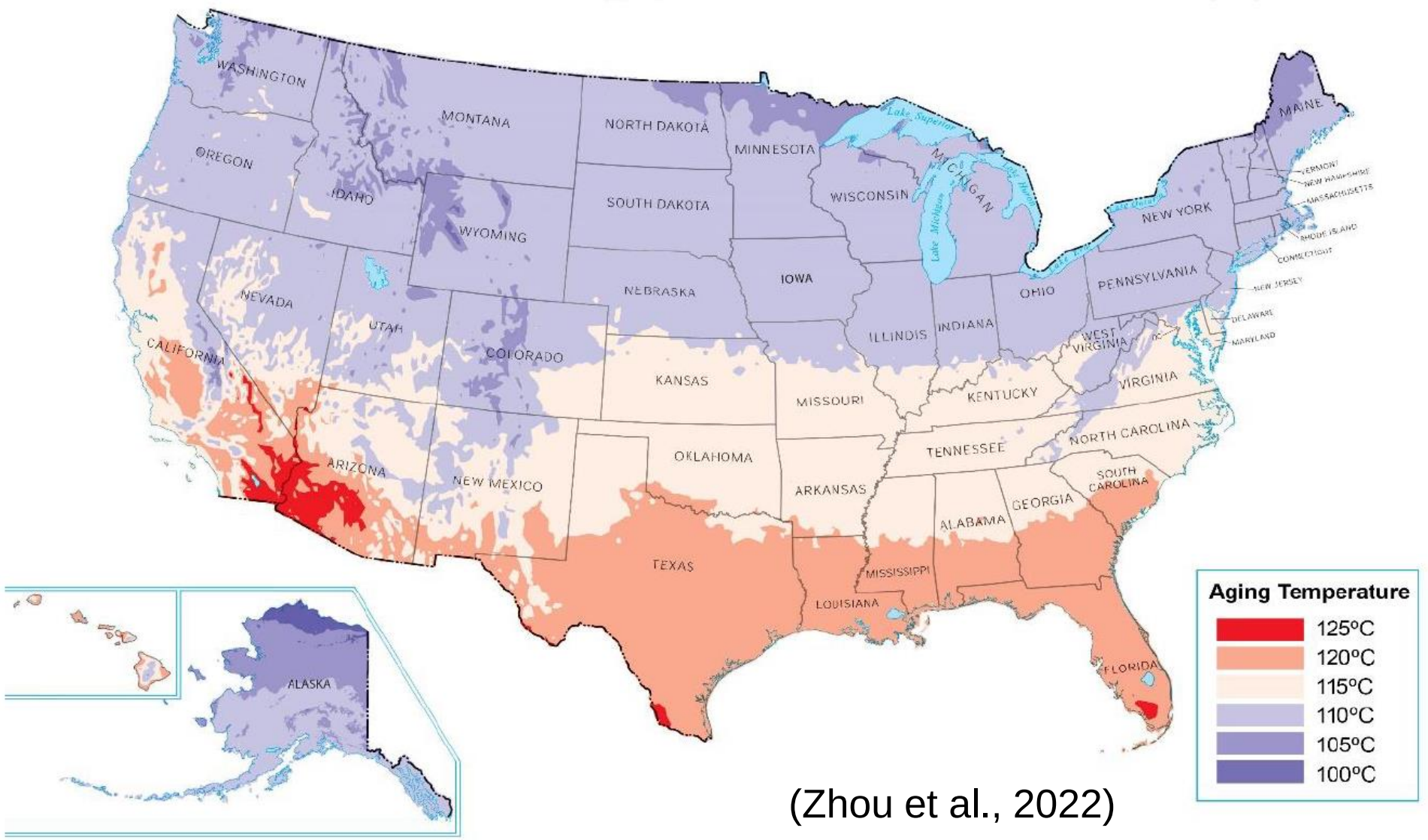
Loose Mix Aging for 20 Hours at 110-120°C

- Developed in at TTI
- Equivalent to 6-day, 95°C loose mix aging in terms of impact on mixture cracking resistance (measured in IDEAL-CT, I-FIT, and OT)
- Expected to simulate 12 years of field aging at 50 mm below pavement surface
- Correlation developed based on IDAEL-CT results (7 mixtures) & NCHRP 09-54 lab-to-field aging maps



110 to 120°C

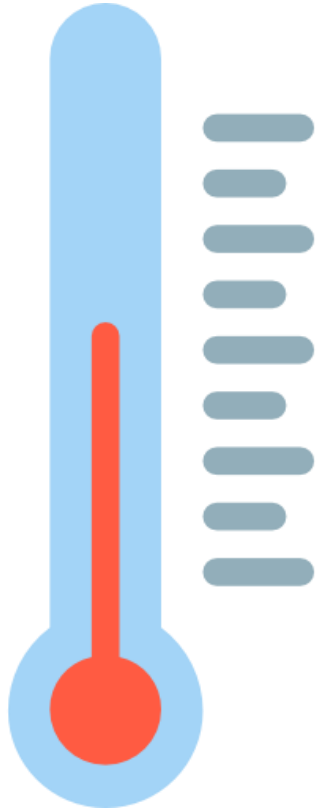
20-hour Loose Mix Aging Map



(Zhou et al., 2022)

Loose Mix Aging at 135°C

- First evaluated at UIUC (and then at AI, MTE, NCAT, UNH, UW-Madison, etc.)
- Aging time varies from 6 to 24 hours
- Lab-to-field aging correlation
  - MTE: 24-hour, 135°C > 6 years of surface aging in Minnesota (3 mixtures from MnROAD)
  - NCAT: 8-hour, 135°C ≈ 5 to 6 years of surface aging in Alabama (4 mixtures from Test Track)
- Limitations
  - Change in oxidation mechanism (for certain binders)
  - Thermal degradation of SBS in HiMA binder



135°C

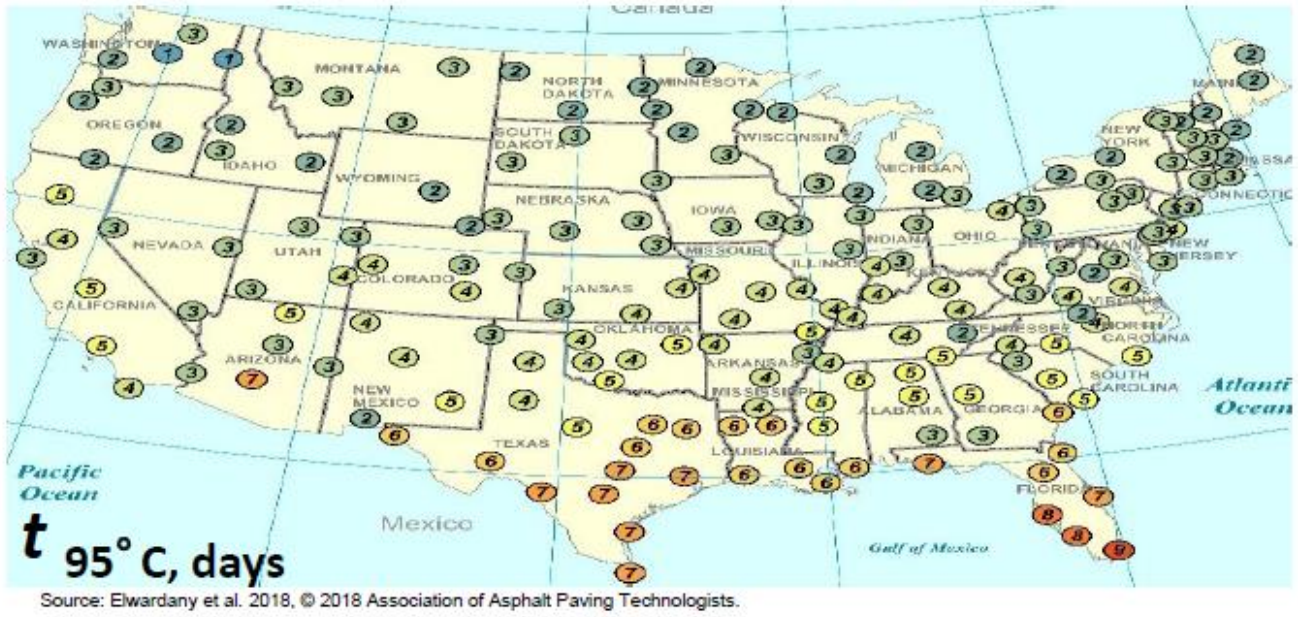
Loose Mix Aging at 95°C vs. 135°C

- Conversation based on NCHRP 09-54 |G*| kinetics model

ASSUMING KINETICS MODELING IS VALID

(Elwardany et al., 2021)

$$[(1-{}^{k_c}/_{k_f})(1-\exp(-k_f t))+k_c t]_{85°C\ or\ 135°C} = [(1-{}^{k_c}/_{k_f})(1-\exp(-k_f t))+k_c t]_{95°C}$$



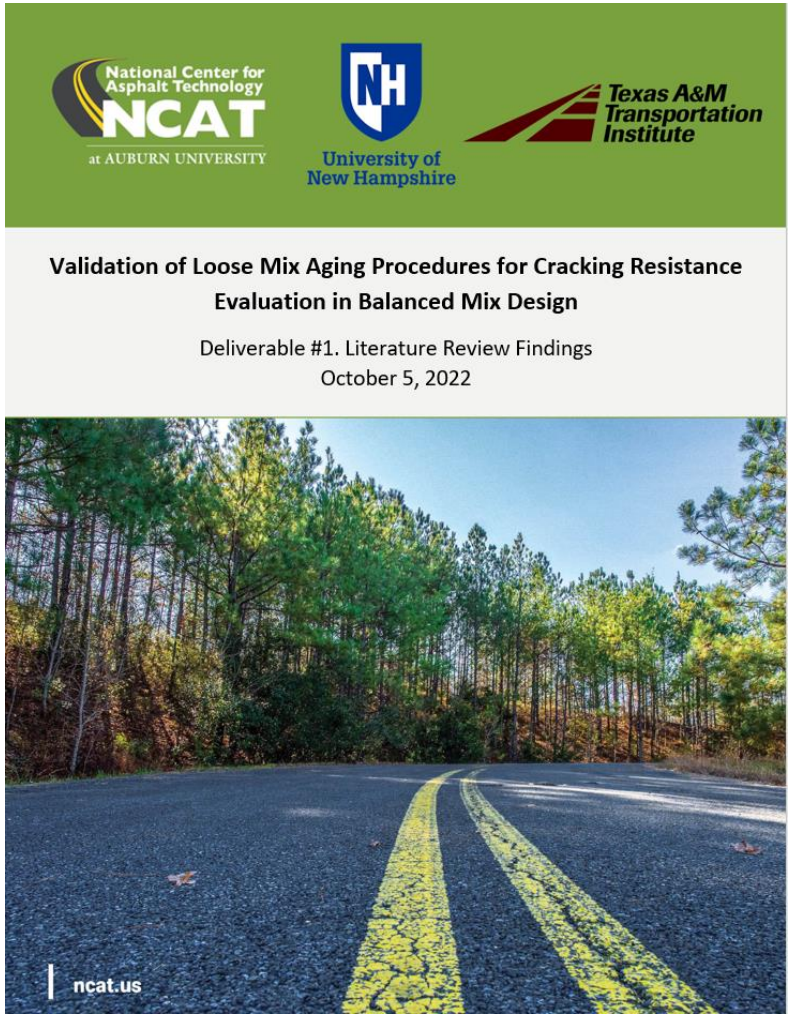
Source: Elwardany et al. 2018, © 2018 Association of Asphalt Paving Technologists.

$t_{85°C}$, days	$t_{95°C}$, days	$t_{135°C}$, hours
2.4	1	1
4.6	2	2
6.8	3	4
8.9	4	6
10.8	5	8
12.7	6	11
14.5	7	15
16.2	8	19
17.9	9	23
19.6	10	27

- In reasonable agreement with lab test results in literature

Other Literature Review Findings

- Most of the existing asphalt binder/mixture performance tests are sensitive to loose mix aging
- Silo storage affects asphalt aging
- Surface weathering affects asphalt aging through different mechanisms from thermal oxidation
- Limited information on the impacts of mix hauling, mix reheating, and specimen storage on asphalt aging



Thank You

Questions?

National Center for Asphalt Technology
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at AUBURN UNIVERSITY