Development of Long-Term Aging Protocol for Implementation of I-FIT (ICT R27-175)

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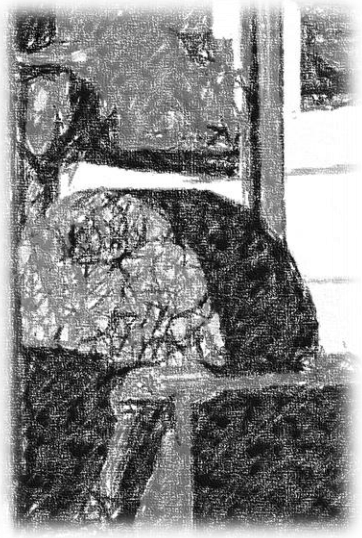

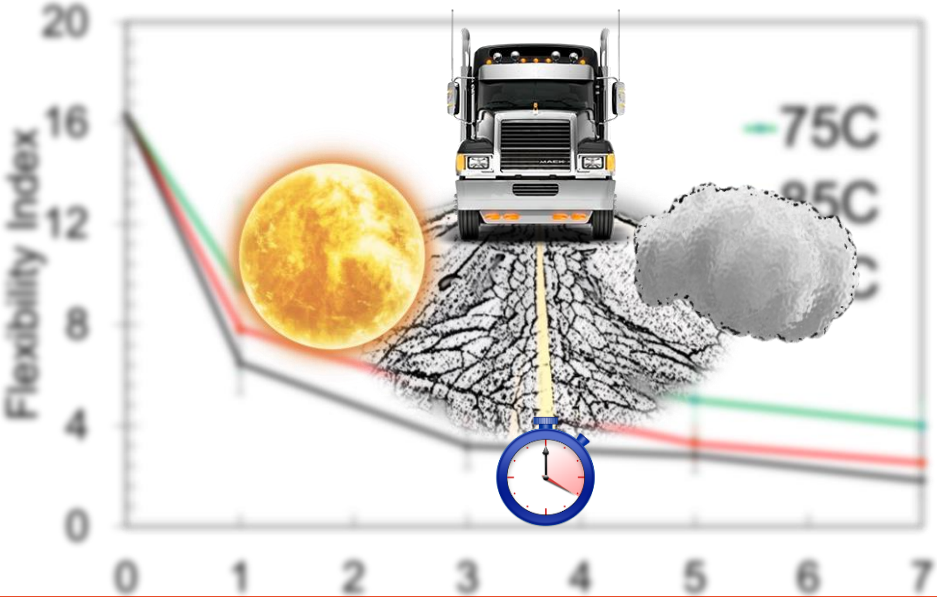

Today's Agenda

1. *Study Motivation*
2. *Nationwide Initiatives on Aging*
3. *ICT R27-175 Project Findings*
4. *Suggested Long-Term Aging Protocol*

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1. *Study Motivation*
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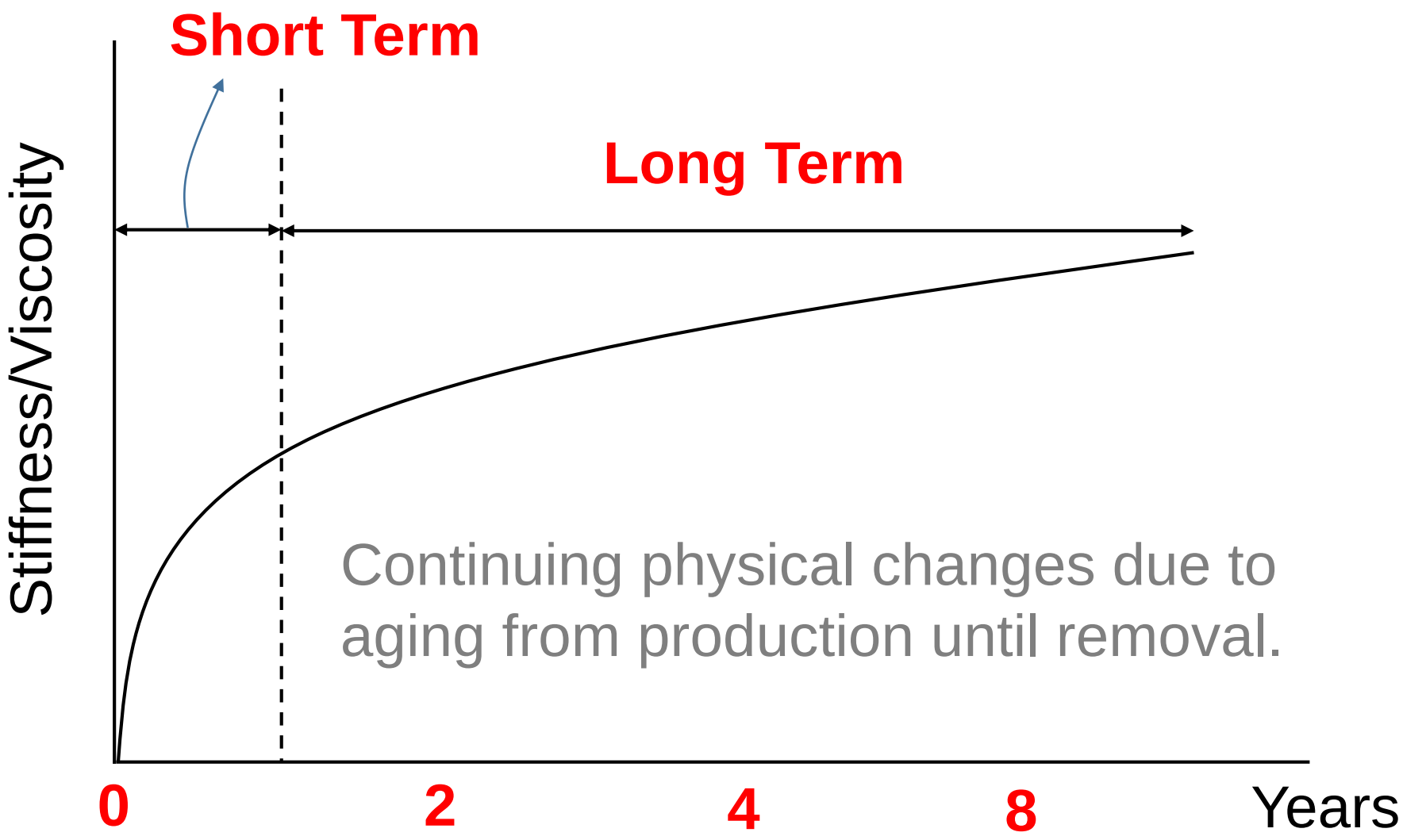
Why Study Aging?

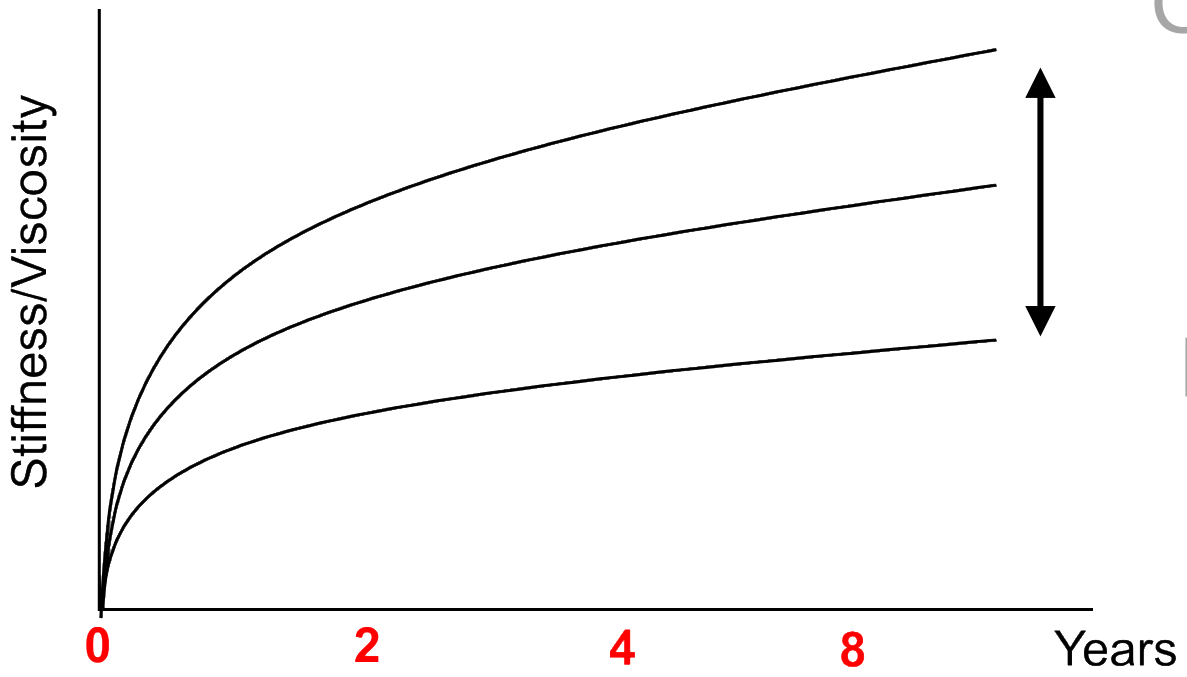
Every asphalt pavement experience aging and aging is often one of the causes of surface distresses.

Phases of Aging



Engineering Aging Performance

Aging performance of pavements can vary.



Controllable:

Binder, mix design, density, thickness

No Control:

Sunlight and temperature

Engineering goal is to use materials with least/acceptable susceptibility to aging for a given location!

Simulation of Aging in the Lab

- A practical and reasonably simulative long-term aging method is needed for:
  - Mix design improvements based on performance testing (e.g. I-FIT)
  - Acceptance
- We have long-term aging methods for binder but modifications are underway!
- No consensus procedure on mixture aging
- Hot research area is on how to accelerate aging in the lab!
  - Duration, temperature, and equipment

Current Standard for Mix Aging

- AASHTO R30
  - Equipment: Force-draft oven
  - Temperature: 85°C
  - Duration: 5 days
  - Gyratory compacted pill

- Shortcomings
  - Difference in aging inside out
  - Specimen distortion
  - Not clearly known what it simulates
  - Too long – Impractical

NCHRP 9-54*: Long-Term Aging Protocols of Asphalt Mixtures

- A calibrated and validated aging procedure for performance testing and prediction
- Force-draft oven
- Aging loose mix
- Temperature is 95°C

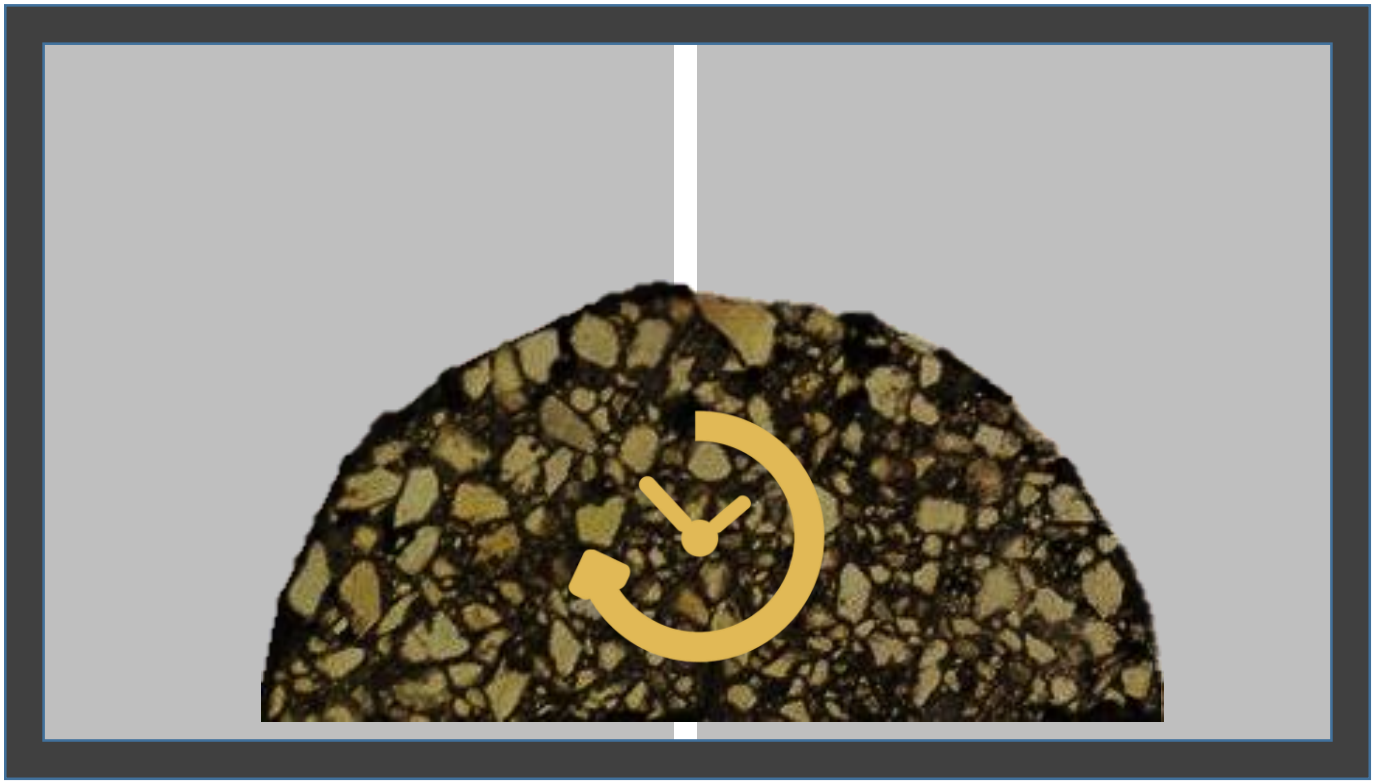
Suggested Duration for Central Illinois:

Depth from Surface	4 years	8 years	16 years
6 mm	3 days	7 days	14 days
20 mm	2 days	3 days	6 days

*Kim, R. et al. (2018)

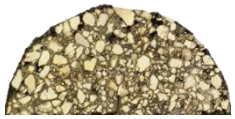
R27-175: Research Objective

Develop a long-term aging protocol specific to IL conditions and determine FI thresholds

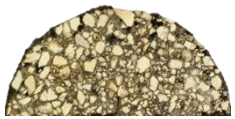


Anticipated Outcome

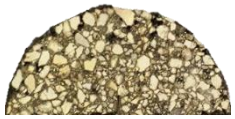
We aimed at a balanced aging protocol:



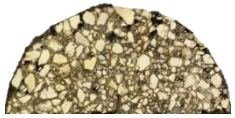
Compatible with I-FIT



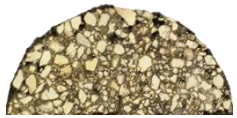
Reliable & Reproducible



Correlates to Field Reasonably



Cost Effective



Practical and Easy to Implement

Scope of Research

12 Plant Mixtures

8 Field-Core Sets

4 Lab Re-produced Plant Mixtures

7 Laboratory Mix Designs

Aging Method Development

PAV

Vacuum Oven

Force-draft Oven

TEAGE: UV Device

Force Draft Oven Aging

Loose Mix

Compacted Specimen

Loose Mix vs. Compacted Specimen

Loose Mix

Pros:
- No aging gradient
- Specimen integrity
- Faster aging

Cons:
- High operation variability
- Controlling air voids

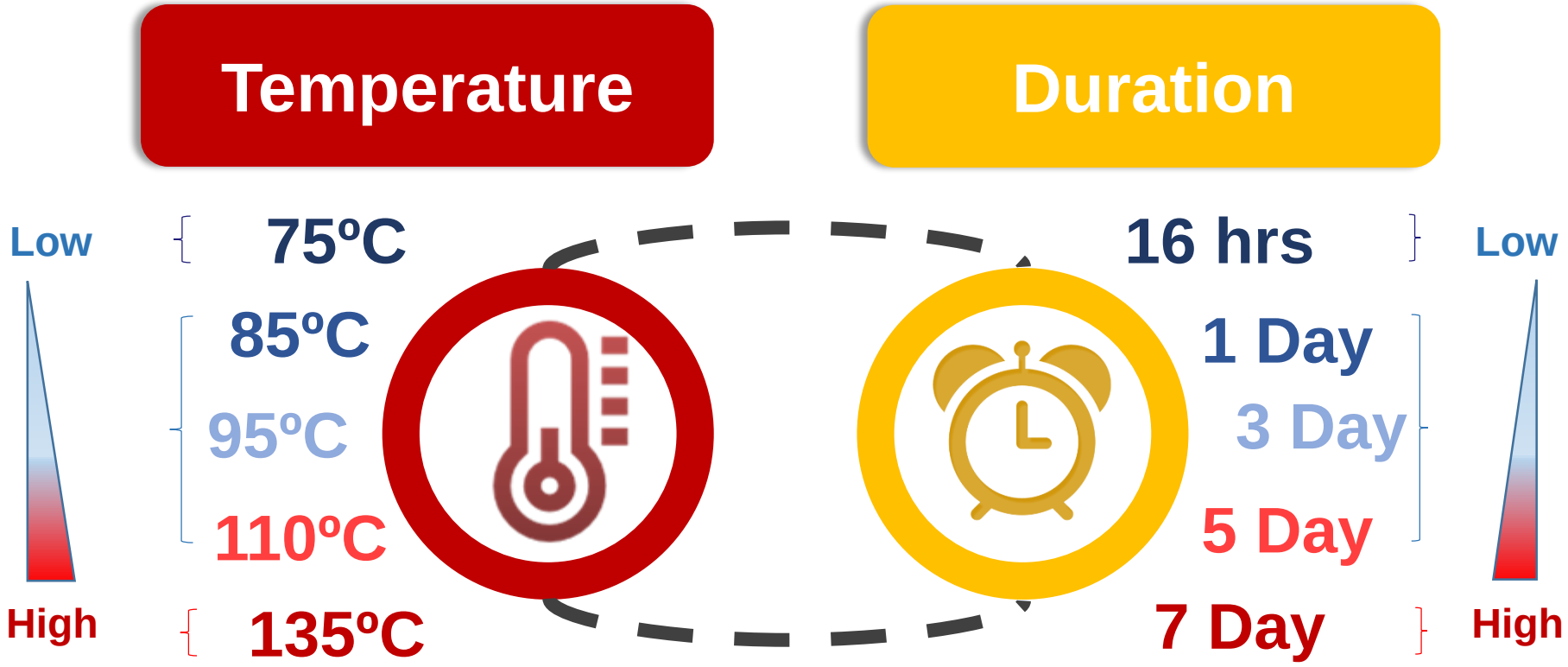
Compacted Specimen

Pros:
- Sample preparation is quick (practical)
- Limited operation variability

Cons:
- Specimen integrity
- Differential aging

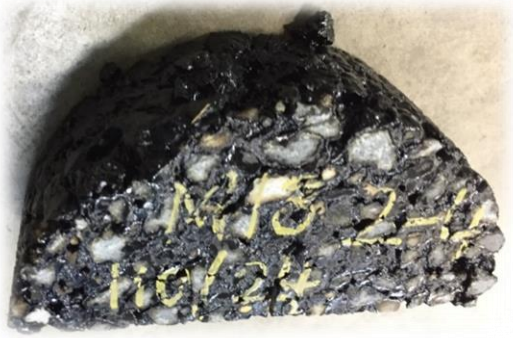
Balancing Temperature and Duration

Temperature and Duration Selection



Constraints for Temperature & Time

- Avoid >100ºC
- Avoid < 80ºC
- 95ºC & 85ºC were considered



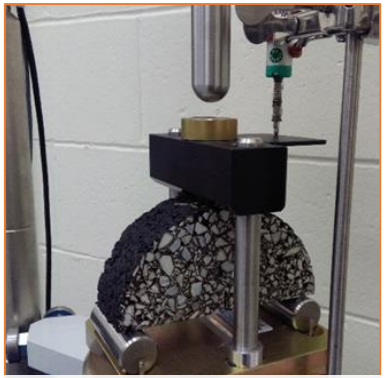
- 5-Day according to AASHTO R30
- Consider option for shorter durations (1 to 3-Day)

Aging Procedure

Prepare I-FIT specimens

Aging in force draft oven

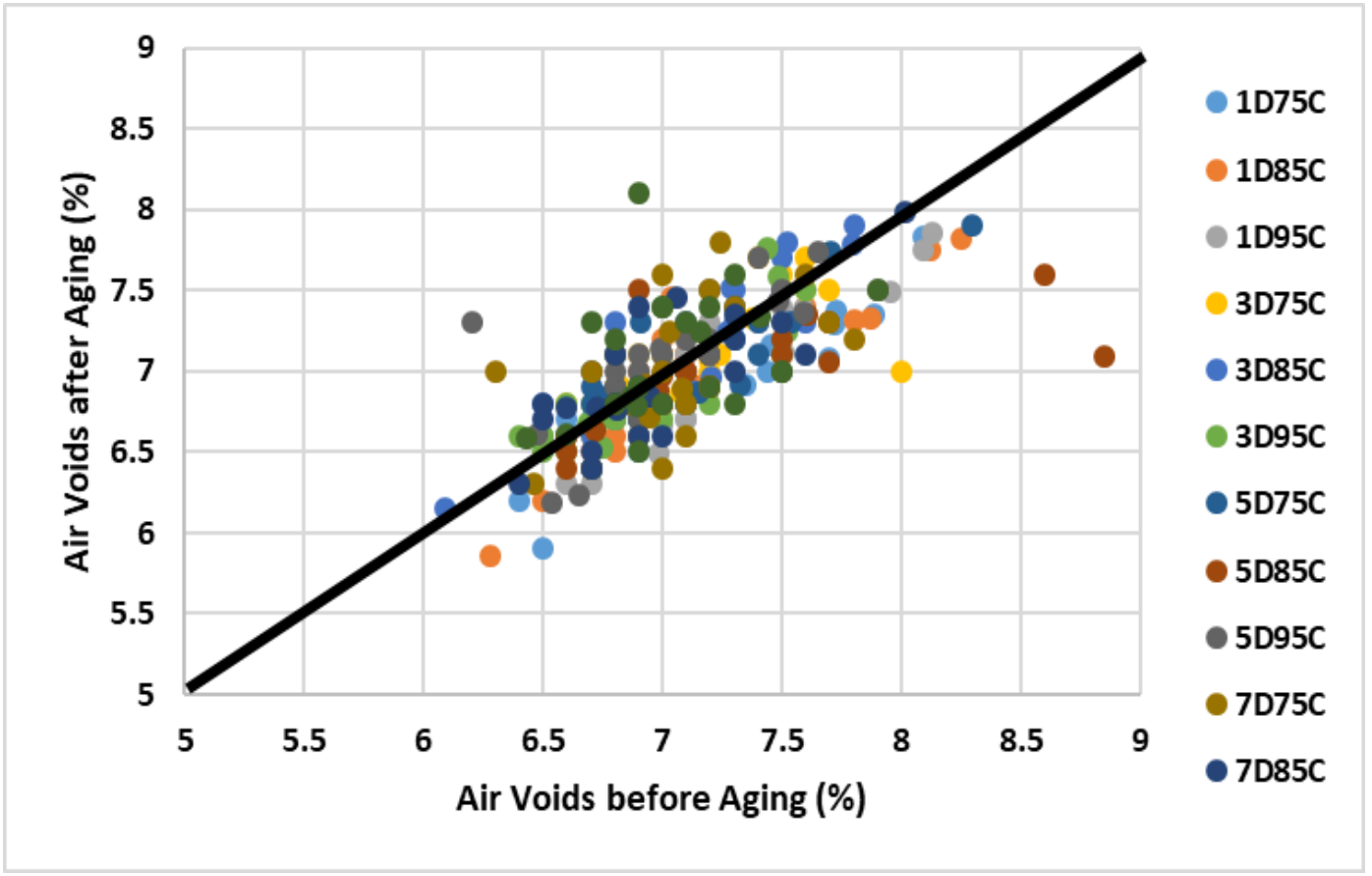
85 and 95°C



Testing to find FI

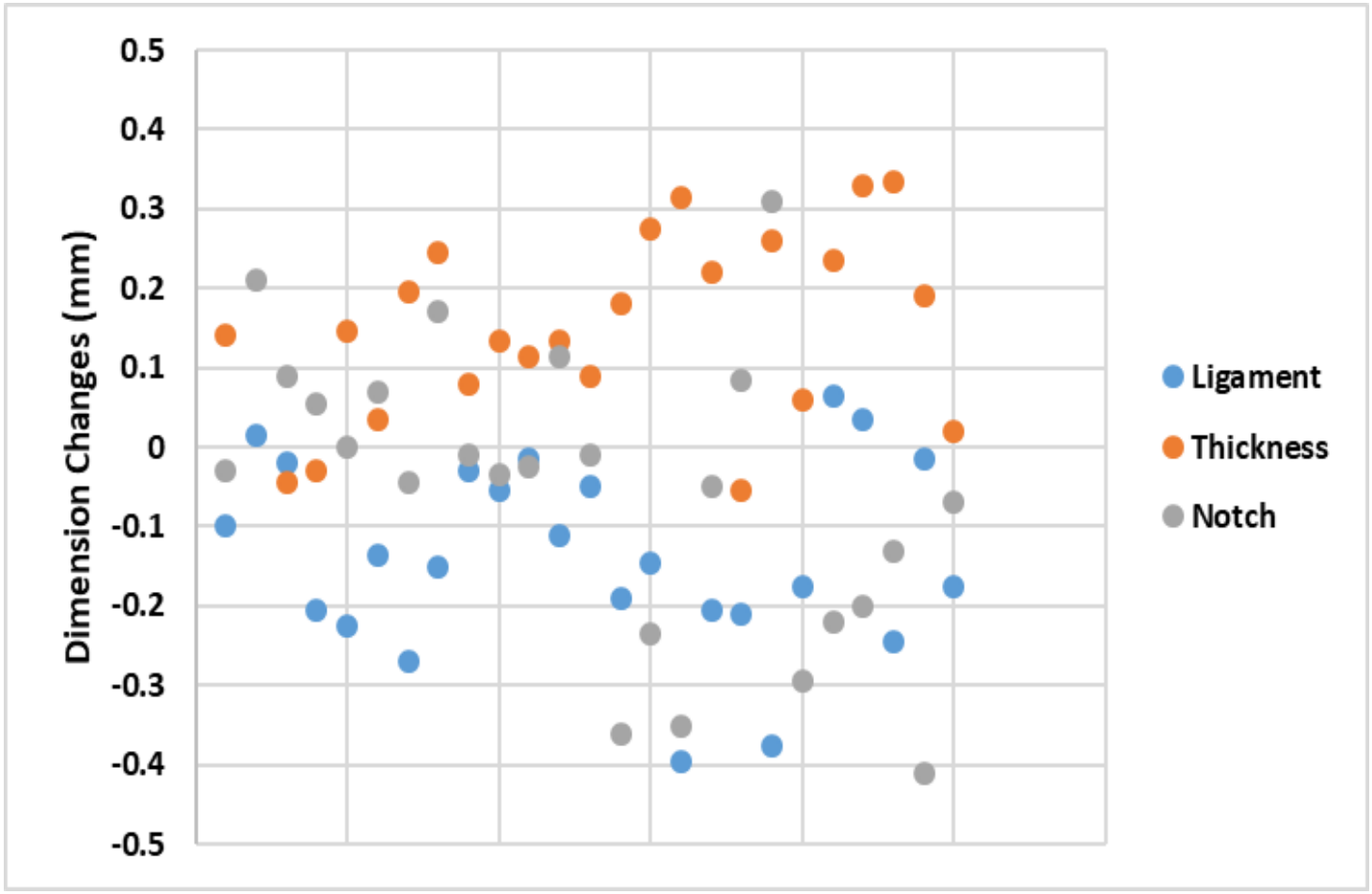
Checking Specimen Integrity

Air voids remained unchanged up to 5 and 7 days of aging.



Checking Specimen Integrity

Specimen dimensions are not affected significantly.



Plant Mix Designs

Plant Mixtures

12 Mixes

Mix ID	N-Design	NMAS (mm)	VMA (%)	AC (%)	Binder PG	ABR (%)	Mix Type
PM1	70	9.5	15.2	5.9	64-22	20.7	DG
PM2	90	9.5	15.1	6.2	70-22	9.2	DG
PM3	90	9.5	15.2	6.2	70-22	9.6	DG
PM5	70	9.5	15.5	6.1	58-28	20.3	DG
PM6	70	9.5	15.7	6.2	64-28	7.9	DG
PM7	80	9.5	16.4	6.4	70-28	30.2	SMA
PM8	50	9.5	15.0	6.0	70-22	15.8	DG
PM9	70	9.5	15.0	5.7	76-28	10.2	DG
PM10	50	9.5	15.2	6.0	76-22	10.2	DG
PM11	50	9.5	15.4	6.0	58-28	24.5	DG
PM12	70	9.5	15.0	6.0	70-28	30.0	DG
PM13	80	12.5	17.3	6.3	70-28	26.7	SMA

Lab Mix Designs

Mix ID	N-Design	NMAS (mm)	VMA (%)	AC (%)	Binder PG	ABR (%)	Mix Type
LM1	70	9.5	15.2	6.4	64-22	0	DG
LM2	70	9.5	15.2	6.4	64-22	0	DG
LM3	70	9.5	15.2	6.4	58-28	20.0	DG
LM4	70	9.5	15.2	6.4	58-28	20.0	DG
LM5	70	9.5	15.2	6.4	58-28	20.0	DG
LM6	70	9.5	15.2	6.4	58-28	26.0	DG
LM7	70	9.5	15.2	6.4	58-28 (ReOB)	26.0	DG

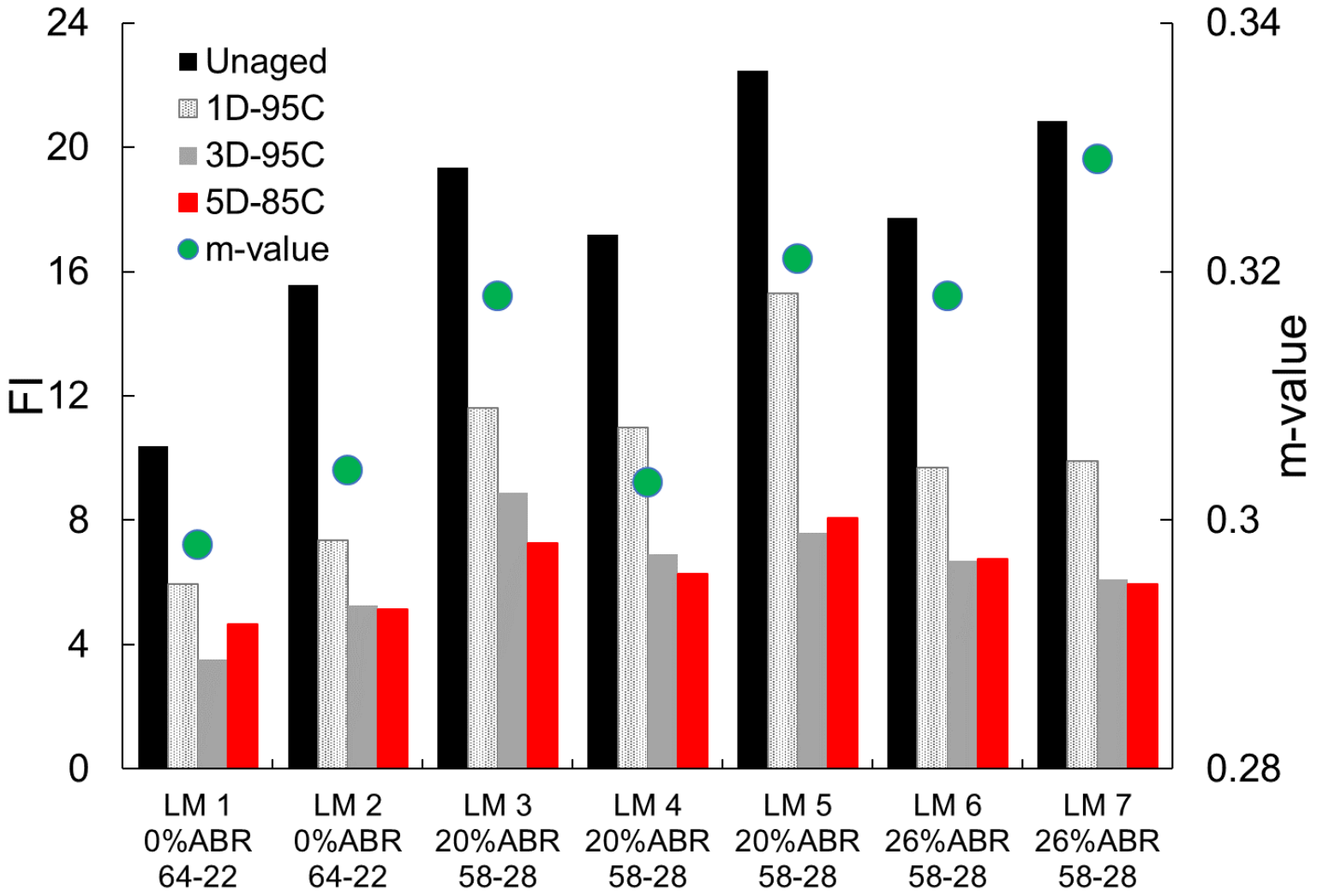
Parameters Considered

Parameters predicting long-term aging performance:

- Flexibility Index (FI) at the desired laboratory age
- Aging Rate to indicate reduction of FI from an unaged condition;

$$\boldsymbol{Aging\ Rate} = \frac{\boldsymbol{FI_{Unaged} - FI_{Aged}}}{\boldsymbol{FI_{Unaged}}}\ \%$$

Effect of Aging on FI

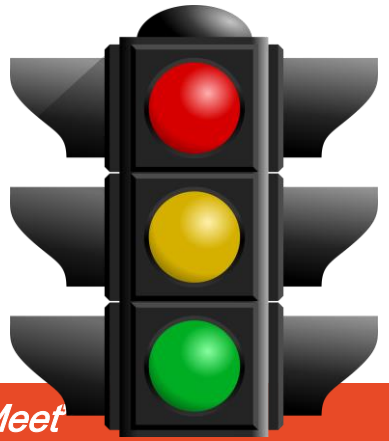


Signals from the Aging Rate

- Aging rate provides supporting data to evaluate aging performance of a mix

Mix ID	FI Unaged	FI @ 1D/95C	% Reduction @ 1D/95C	FI @ 3D/95C
PM1	4.1	1.1	74%	0.1
PM2	16.3	6.8	58%	3.2
PM3	12.8	8.1	37%	3.5

Low FI AND Rapid Drop
High FI BUT Rapid Drop
High FI AND Slow Drop



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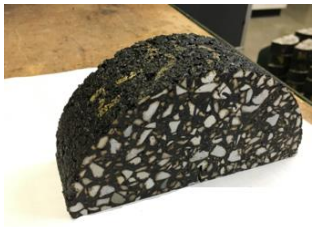
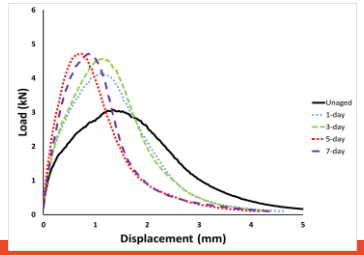
Overview of Aging Protocol

IL Long-Term Aging Protocol

- Lab Produced Lab Compacted
- Plant Produced Lab Compacted

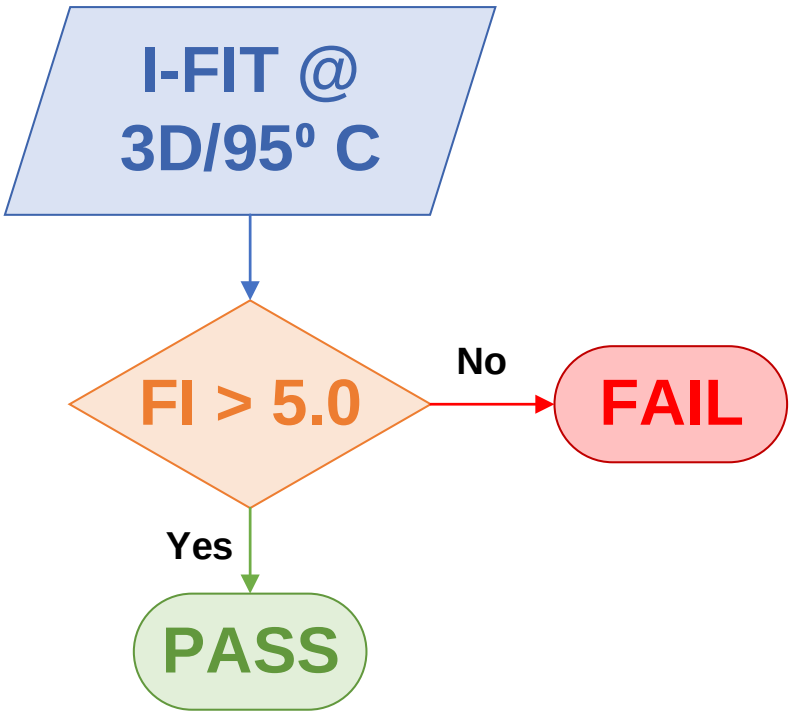




1. Age specimens 1-D or 3-D at 95°C
2. I-FIT to calculate FI and aging rate
3. Compare against thresholds
4. Pass or fail decision on the mix

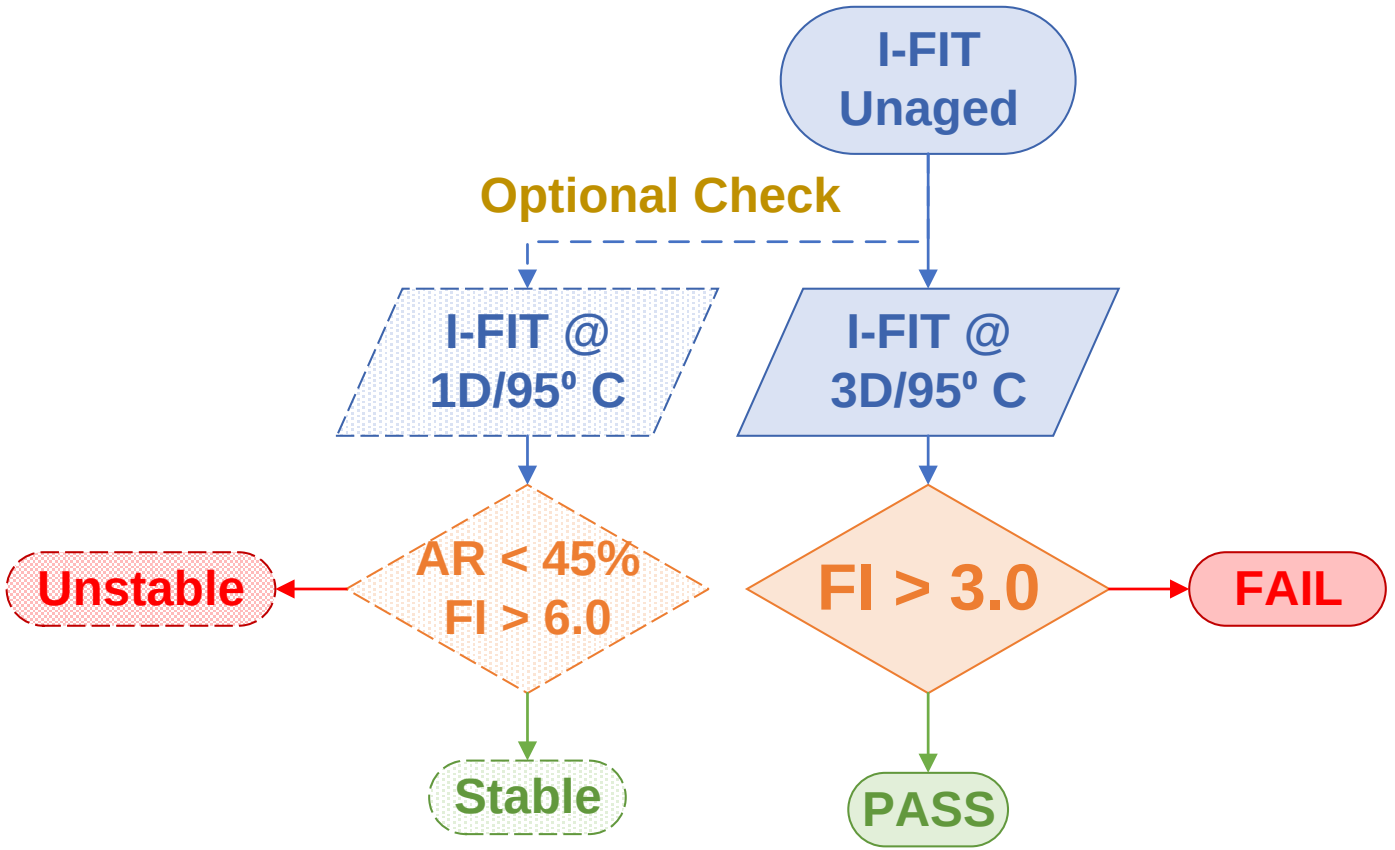
Protocol for Lab Mixes

Suggested Long-Term Aging Protocol Laboratory Designed AC Mixtures



Protocol for Plant Mixes

Suggested Long-Term Aging Protocol Plant-Produced AC Mixtures



Project Findings

- 3D-95ºC is an acceptable aging temperature in a forced draft oven
  - No need to wait for 5 days (AASHTO)
- 1D-95ºC may be used to screen mixes for rapid FI changes during plant production
- Binder source and m-value has some measurable effect on aging performance
- Aging protocol can produce repeatable performance test results

Acknowledgement

- Graduate students: Zehui Zhu, Punit Singhvi, Mohammed Sawalha
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- IDOT TRP

Thank You

Any Questions?

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