Comparison of Different Laboratory Aging Methods for Performance Evaluations

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Aging

- Hot mix asphalt pavements undergo aging during mixing and compaction, and over the service life.
 - Short term aging (mixing and compaction)
 - Long term aging (pavement service life)



- Aging effects:
 - Increase of stiffness
 - Decrease of relaxation
 - Increase of brittleness



More cracking susceptibility



Project Overview

- NHDOT Project 26962O
- I0 plant mixed, lab compacted mixtures
 - PG 58-28, PG 52-34
 - 12.5 and 19 mm NMAS
 - 20 and 30% RAP, RAP/RAS
- Binder testing
- Mixture testing

Objectives

- To investigate how mixtures linear viscoelastic (LVE), fracture, and fatigue properties change with different aging levels.
- To investigate impact of different long term lab conditioning protocols.





Laboratory Aging

- ✓ Short-term aging condition
- ✓ Long-term aging condition
 - 5 days, 85 $^\circ\!\mathrm{C}$ for compacted samples (AASHTO R30)
 - 5 days, 95 °C, loose mix (NCHRP 9-54 project)
 - 12 days, 95 °C, loose mix (NCHRP 9-54 project)
 - 24-hour, 135 °C, loose mix (Asphalt Institute)







- Complex Modulus Testing (AASHTO TP-79)
 - IE*I and δ master curve
 - Black Space Diagram
 - Higher E* and lower $\delta \rightarrow$ more potential to cracking







LVE Characteristics



- Higher dynamic modulus and lower phase angle for LTOA mixtures.
- Change of phase angle master curve shape; horizontal and vertical shift in peak phase angle



LVE Characteristics



- Higher stiffness for LTOA mixtures (difference varies between 1 to 6 times).
- Lower relaxation at high and intermediate freq. and higher relaxation at low freq. for LTOA mixes.



Black Space Diagram



 For same level of thermal stress, relaxation capabilities of asphalt mixtures would diminish with increasing aging levels.

Mixture G-R Parameter



- Increase of the ratio in higher aging levels.
- 12 days (95 °C) and 24 hr. (135 °C) have similar values.



- Uniaxial Fatigue Testing
- Based on Simplified Viscoelastic Continuum Damage approach (AASHTO TP 107)
 - Damage Characteristics Curve (C S)
 - Fatigue Failure Criterion $(G^R N_f)$
 - N_f @ G_R=100

 G^R: The rate of change of the averaged released pseudo strain energy (per cycle) throughout the entire history of the test.







100000

10000

1000

10

1000000

Fatigue Properties (C-S)



- Similar integrity for STOA and 5 days LTOA, but high levels of aging make significant difference.
- Similar C-S curves for PG 58-28 and PG 52-34 mixtures.



- Disk-Shaped Compact Tension (DCT) Test (ASTM D7313-13)
- Semi-Circular Bend (SCB) Test (AASHTO TP 124)
 - Fracture Energy (G_f = work / fracture surface area)
 - Flexibility Index (FI = G_f / Slope at inflection point)
 - Fracture Strain Tolerance (FST = G_f / Fracture strength)







Fracture Properties, $FST = (G_f/S_f)$



- Higher FST for 5 days aging than 12 days.
- 24 hr. have higher FST than 12 days for RAP/RAS mixtures.



Conclusion

- All levels of long term aging have made a significant increase on LVE properties (IE*I and δ)
- 24 hour (135 °C) and 12 days (95 °C) aging levels create similar effects on LVE properties, but not on fatigue and fracture properties.
- Cracking resistance (FST) decrease as the aging level changes from 5 days to 12 days, but there is not an evident trend between the fracture properties of 24 hour and 12 days.
- This study supports 12 days at 95 °C aging protocol on basis of fracture test results.

Future Work

- Expand the data base, additional mixtures from different locations of country.
- Testing and analysis of cores that have been aged in the field.
- Extend this research to develop an aging prediction model.
- Develop new thresholds for available cracking parameters with the effect of aging.



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Thank you!

any questions?

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Shape Parameters



- The evolution of shape parameters with aging.
- More variation in 24 hr., 135°C aged mixtures.



Fracture Properties, FI (SCB)



