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Safer, Smarter, Sustainable Pavements Through Innovative Research

National Center for Asphalt Technology

NCAT

at AUBURN UNIVERSITY

Evaluation of Spray-on Rejuvenators ***Section S3***

MDOT

MISSISSIPPI DEPARTMENT OF TRANSPORTATION

2022 Spring Sponsor Meeting

May 11, 2022

Objective

- Evaluate over time the field performance of two spray-on rejuvenator products commercially available in the United States

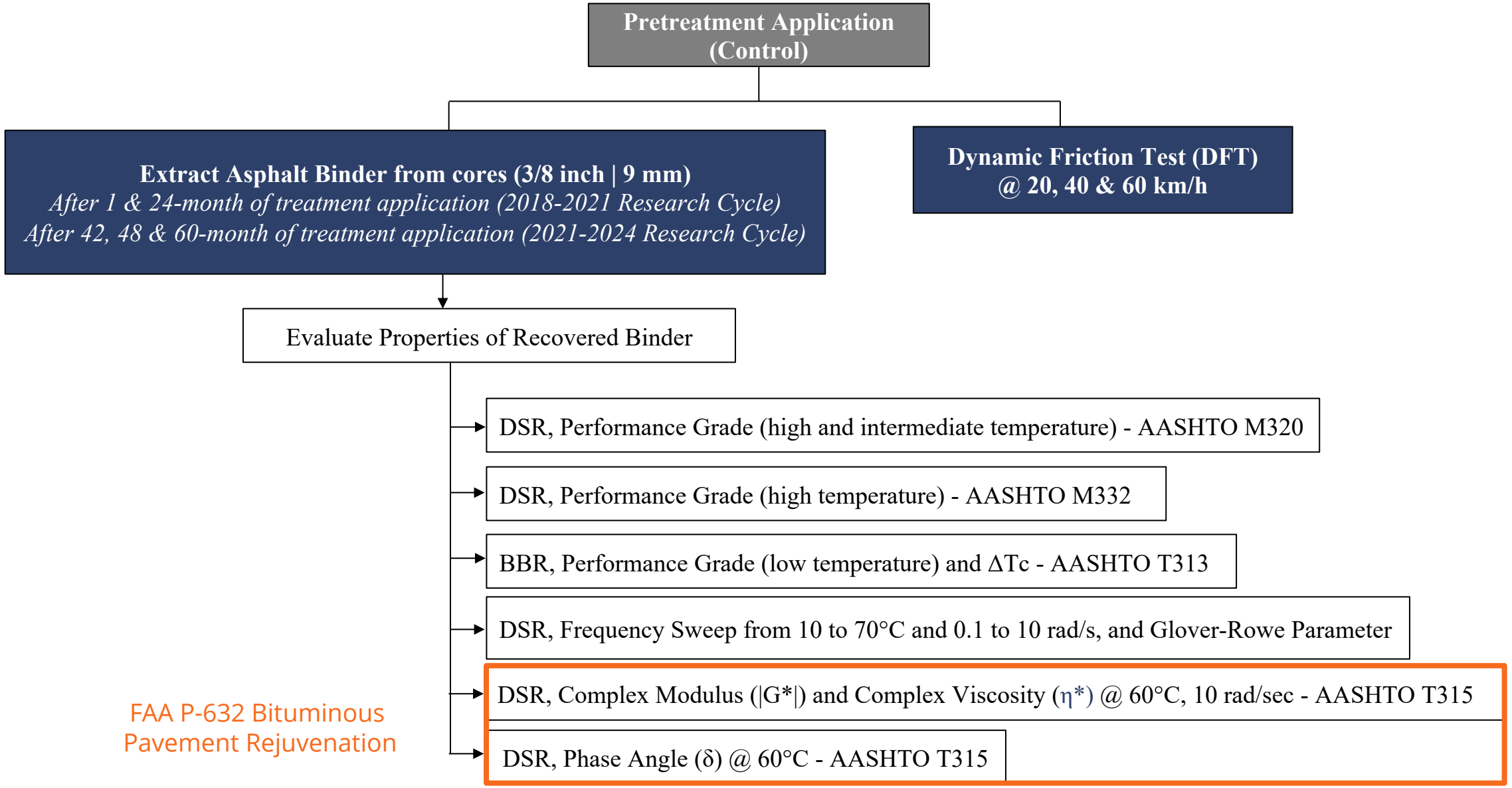
Spray-on Rejuvenators

- Petroleum- or bio-based oils with chemical and physical characteristics selected to restore properties of hardened/oxidized asphalt binder in the surface layer
- Can be combined with emulsified asphalt binders (to produce rejuvenating fog seals) and/or other materials (e.g., polymers) to seal low-severity surface cracks and inhibit raveling

Materials – Section S3, Mississippi DOT

- Dense-graded mix with sand and gravel containing 25% RAP, constructed in 2012 (ten-year-old pavement)
- Asphalt content = 6.8% (PG 67-22 neat)
- Spray-on rejuvenator products were applied after Section S3 was subjected to a total of ≈20.0 million ESALs of traffic since construction

Surface Treatment	*Composition*	*Product Use by Manufacturer Recommendation*	*Dilution Rate*	*Residual Application Rate*
S3-A	Proprietary	Age-regenerating surface treatment	2:1	0.014 gal/yd^2
S3-B	Plant-based rejuvenator	Topical rejuvenating seal	Undiluted	0.020 gal/yd^2



FAA P-632 Bituminous Pavement Rejuvenation

After Surface Treatment Application

Extract Asphalt Binder from cores (3/8 inch | 9 mm)
After 1, 6, 12, 18 & 24-month of treatment application (2018-2021 Research Cycle)
After 30, 42, 48 & 60-month of treatment application (2021-2024 Research Cycle)

Evaluate Properties of Recovered Binder

- DSR, Performance Grade (high and intermediate temperature) - AASHTO M320
- DSR, Performance Grade (high temperature) - AASHTO M332
- BBR, Performance Grade (low temperature) and ΔTc - AASHTO T313
- DSR, Frequency Sweep from 10 to 70°C and 0.1 to 10 rad/s, and Glover-Rowe Parameter
- DSR, Complex Modulus (|G*|) and Complex Viscosity (η*) @ 60°C, 10 rad/sec - AASHTO T315
- DSR, Phase Angle (δ) @ 60°C - AASHTO T315

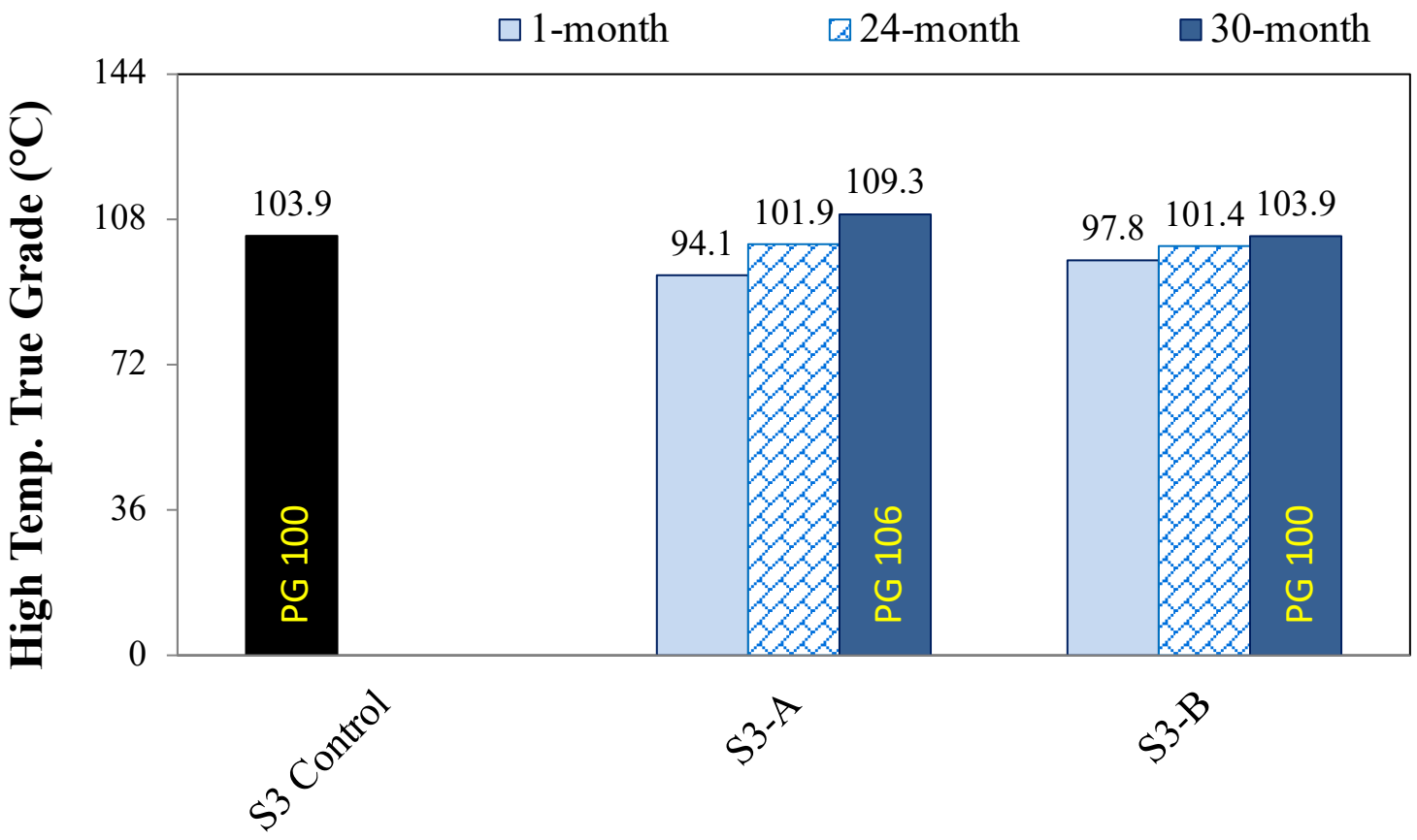
Dynamic Friction Test (DFT)
@ 20, 40 & 60 km/h

After 96-hour, and 1, 6, 12, 18, 24, 30, 42, 48 & 60-month of treatment application

FAA P-632 Bituminous Pavement Rejuvenation

Superpave Performance Grade Classification – ***High-Temperature***

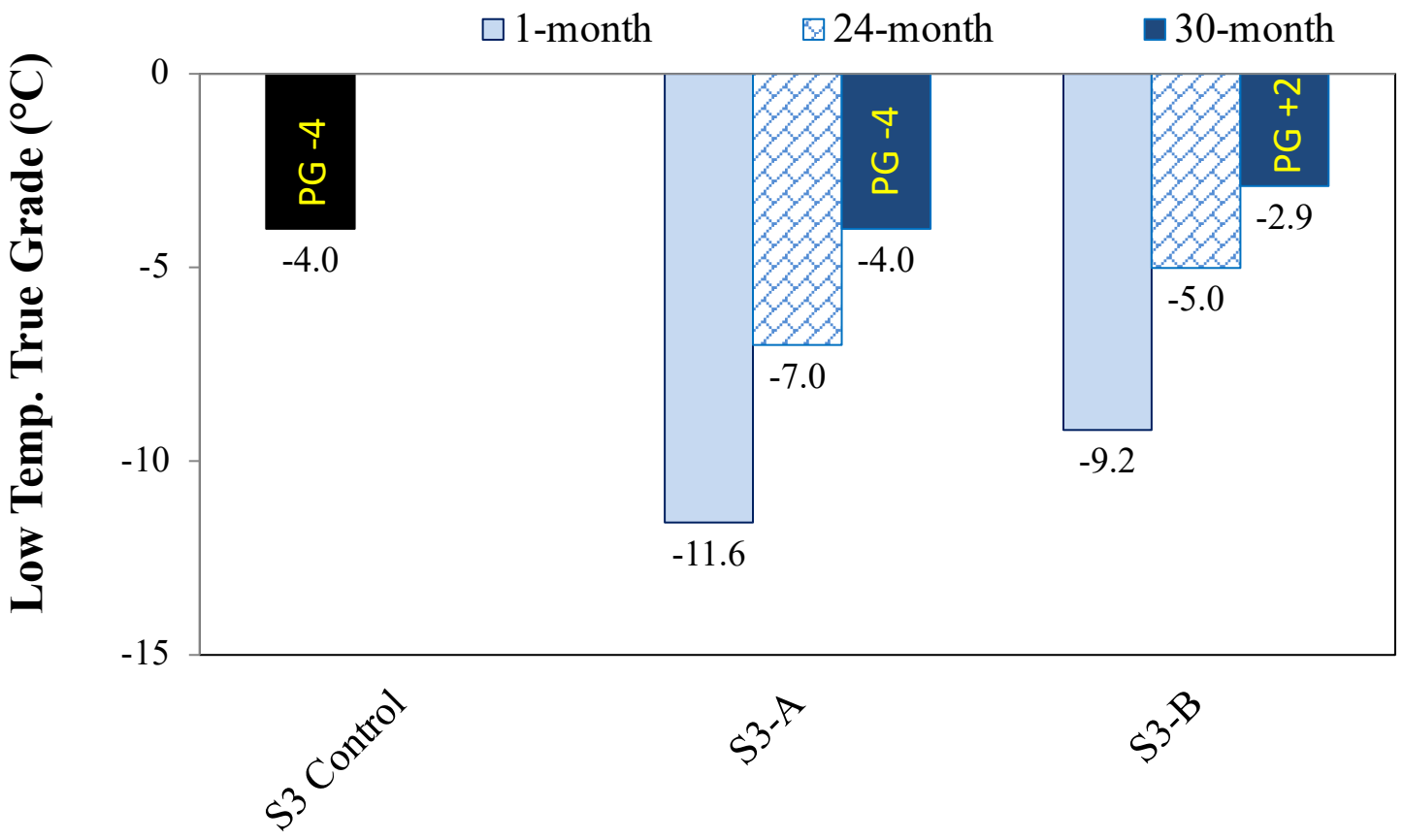
observed change after treatment application



- Up to 24-month after treatment application, a decrease in the high pass/fail temperature of the control binder was observed.
  - *S3-A*: After 30-month of treatment application, the HT PG was higher than the control.
  - *S3-B*: After 30-month of treatment application, the HT PG was equal to the control.

Superpave Performance Grade Classification – ***Low-Temperature***

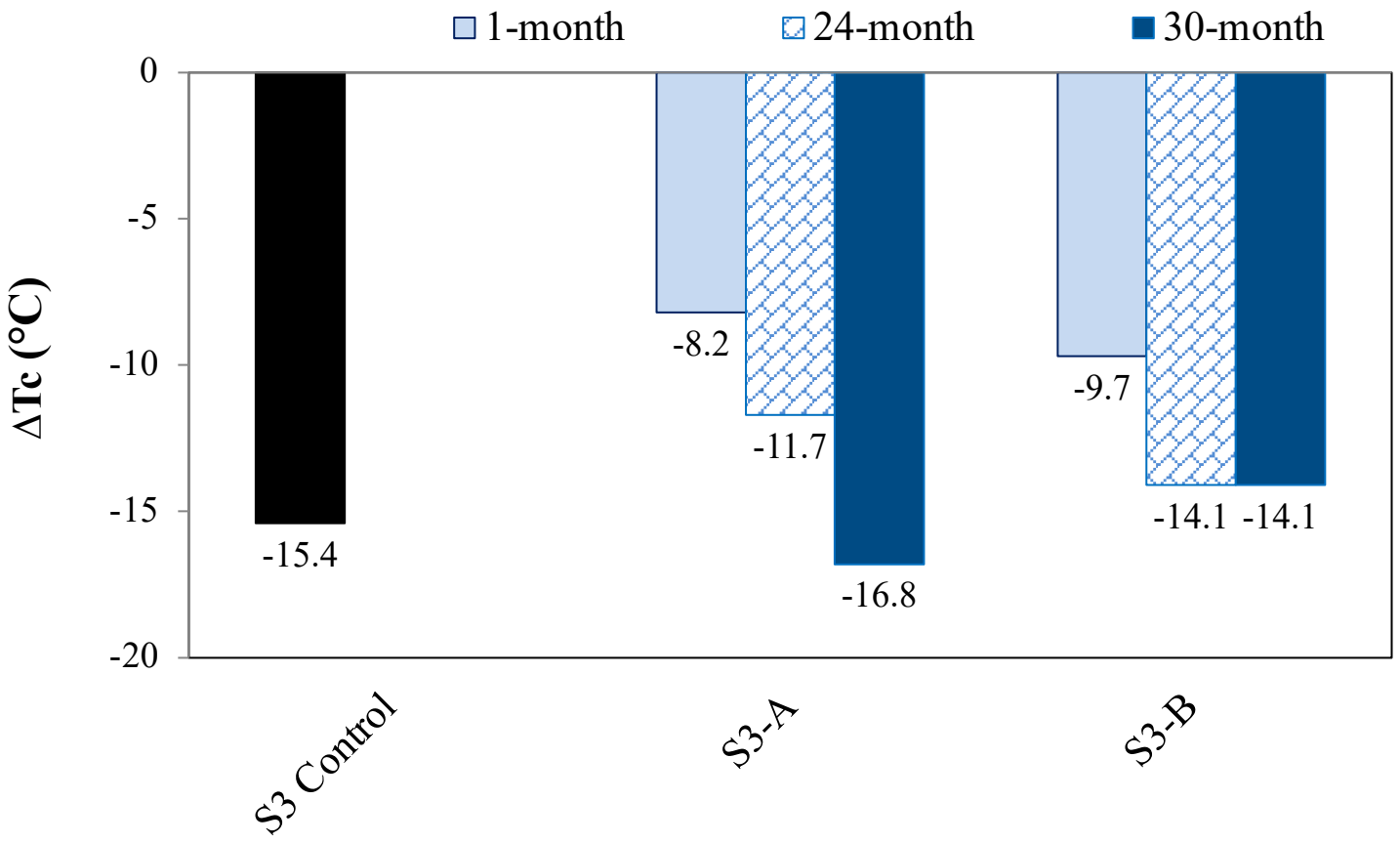
observed change after treatment application



- Up to 24-month after treatment application, a decrease in the low pass/fail temperature of the control binder was observed.
  - S3-A: After 30-month of treatment application, the LT PG was equal to the control.
  - S3-B: After 30-month of treatment application, the LT PG was higher than the control.

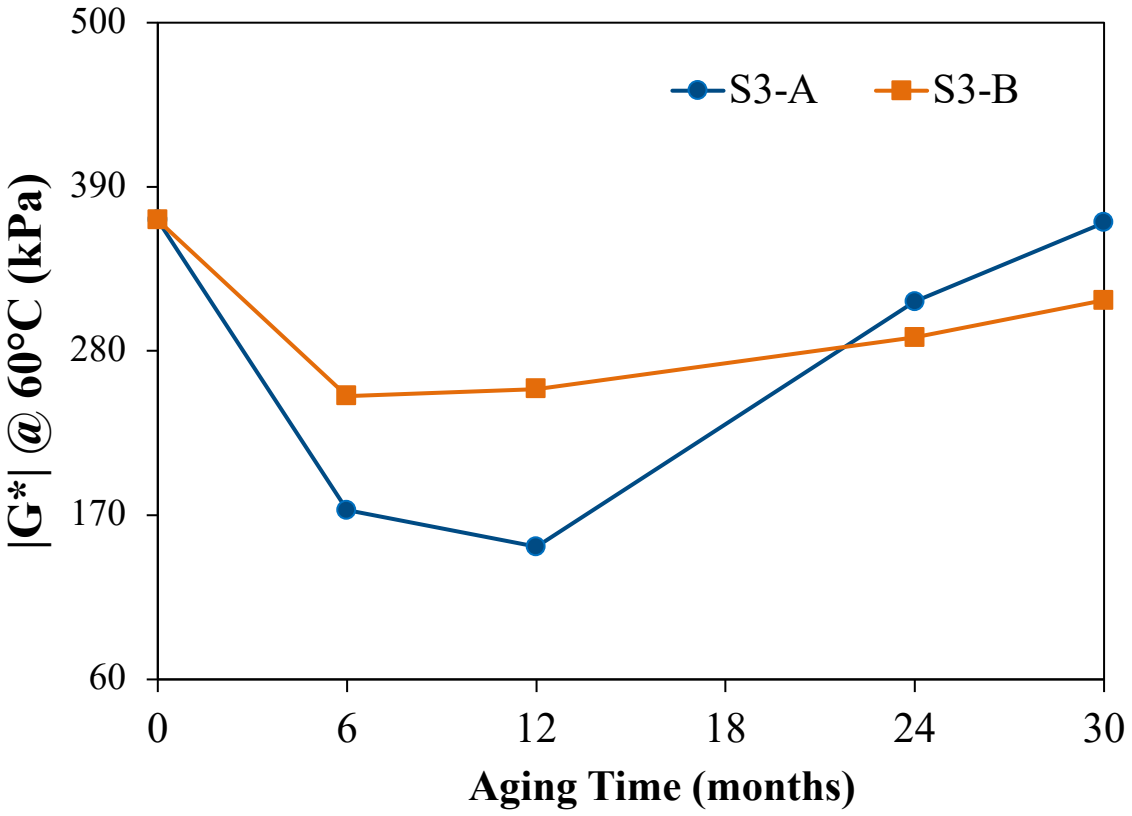
ΔT_c parameter – ***Low-Temperature***

observed change after treatment application



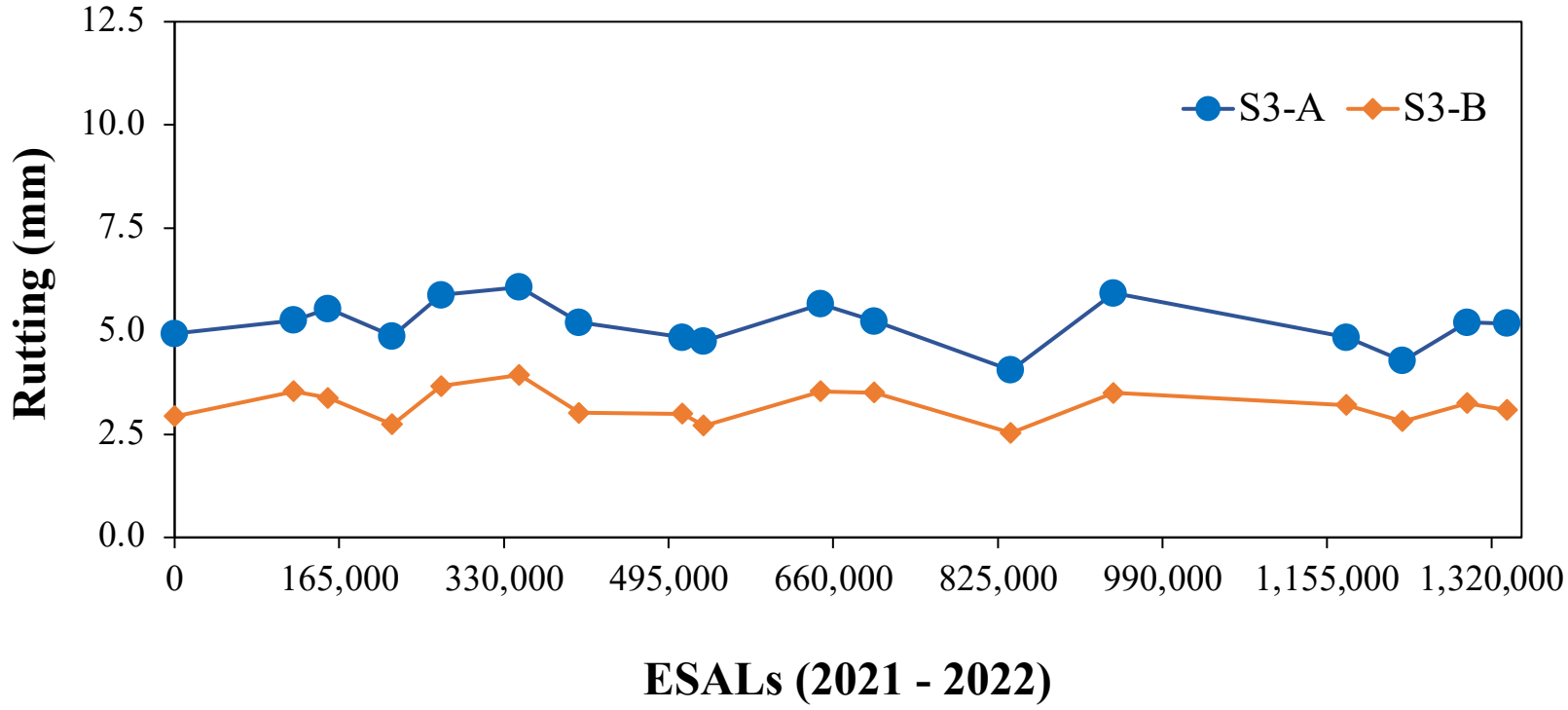
- Product S3-A improved ΔT_c (less negative) up to 24-month after treatment.
- Product S3-B improved ΔTc (less negative) 30-month after treatment.

Complex Modulus (|G*|) at 10 rad/s at 60°C
FAA P-632 evaluation parameter



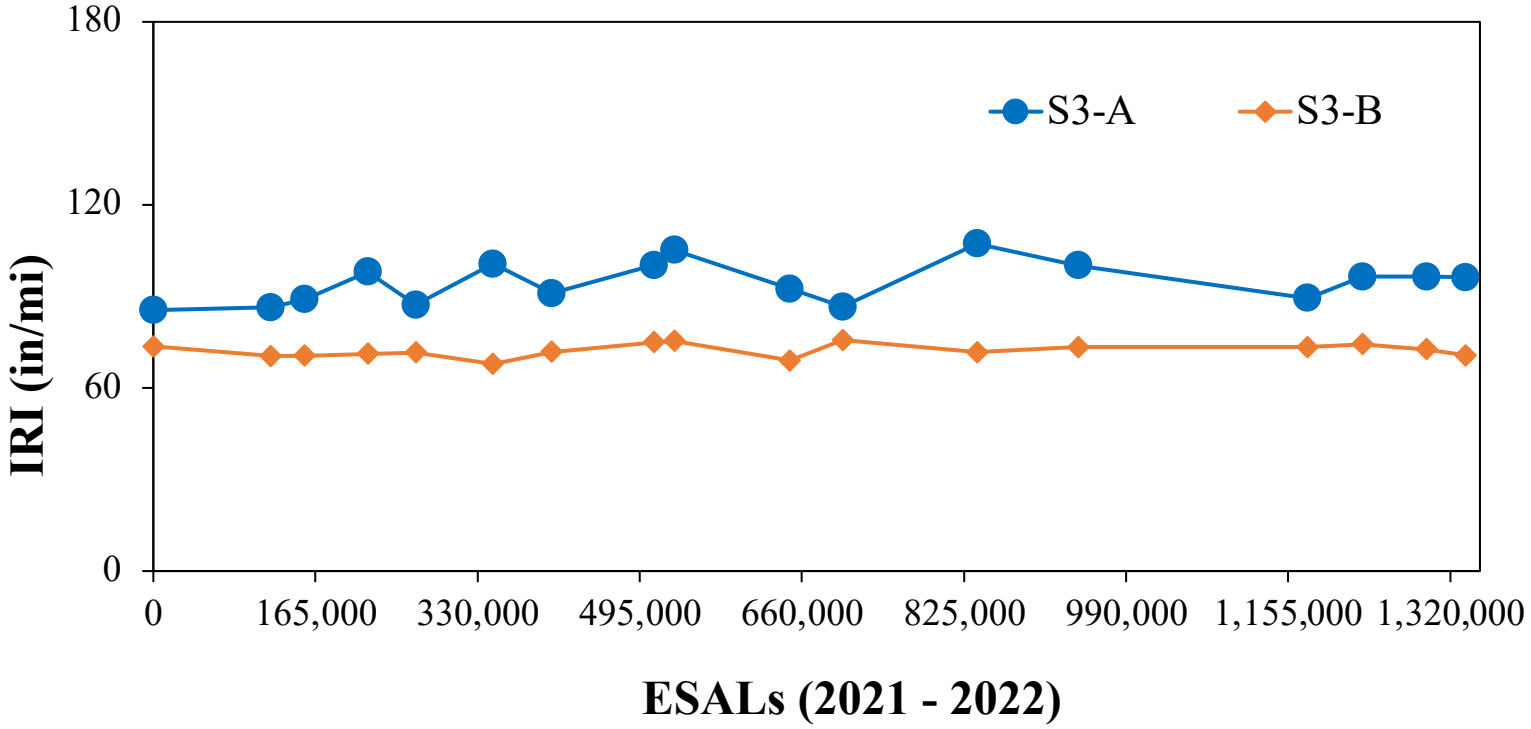
- Maximum rejuvenating capability of the applied spray-on rejuvenator products was achieved between 6 and 12 months of treatment application.
  - S3-A: 12-month, 59.5% decrease in |G*| of control.
  - S3-B: 6-month, 32.1% decrease in |G*| of control.
- 24 months of field aging was required to differentiate among products.
- After 30-month field aging interval:
  - S3-A: 0.4% decrease in |G*|of control.
  - S3-B: 14.6% decrease in |G*|of control.

Field Performance - Rut Depth *versus* ESALs



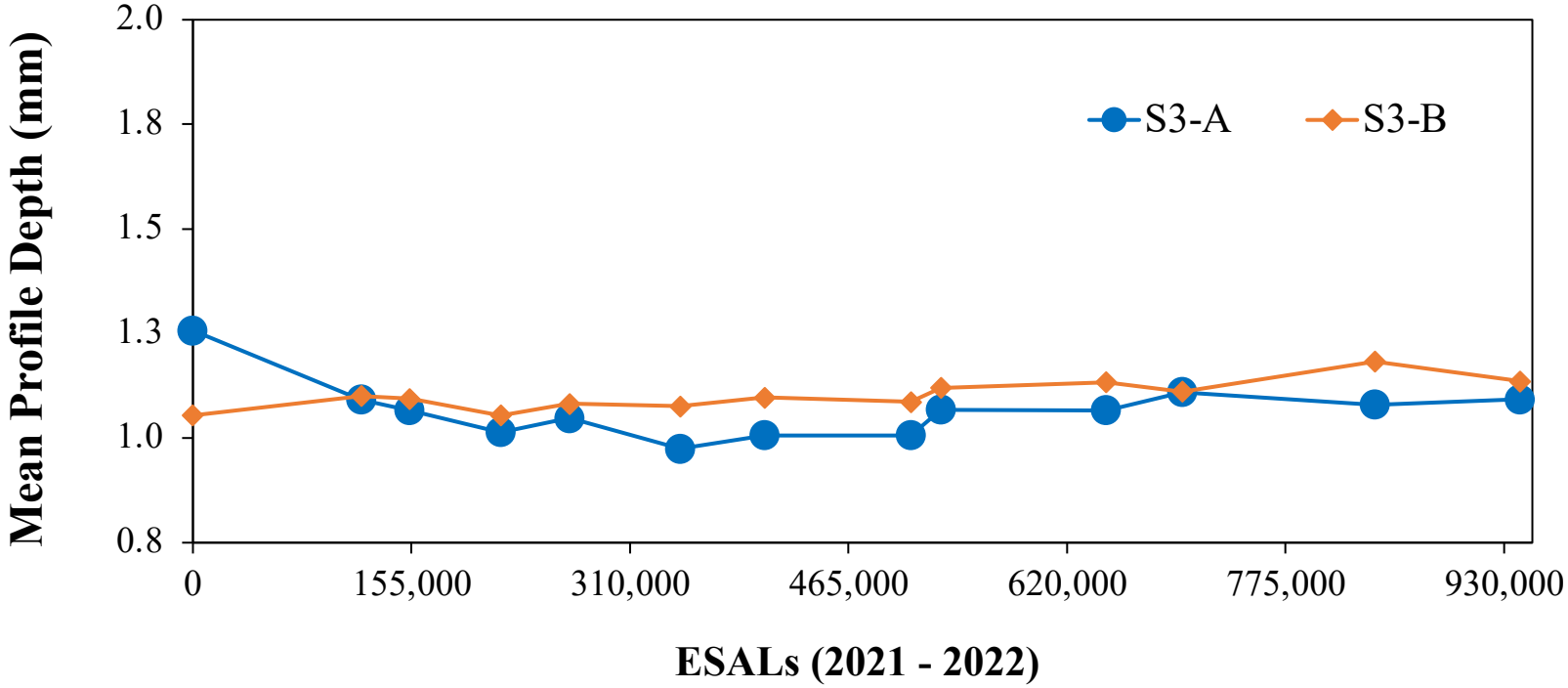
- Average rut depth for ≈1.3 million ESALs of traffic (≈31.3 million ESALs since construction)
  - S3-A = 5.2 mm
  - S3-B = 3.2 mm
- Obtained field rut values were smaller than the rut depth limit of 12.5 mm

Field Performance - Roughness *versus* ESALs
quantified using the International Roughness Index (IRI)



- Overall IRI for ≈1.3 million ESALs of traffic (≈31.3 million ESALs since construction)
  - S3-A = 94.6 in/mile
  - S3-B = 72.3 in/mile

Field Performance - Mean Profile Depth *versus* ESALs



- Overall MPD for ≈1.0 million ESALs of traffic (≈31 million ESALs since construction)
  - S3-A = 1.1 mm
  - S3-B = 1.1 mm

Conclusions

- After 30 months of the application of the spray-on rejuvenator products, the asphalt binder properties of the treated sections are equivalent or “improved” when compared to the control section.
  - This improvement was found as dependent of the spray-on product type, and was influenced by the characteristics of the asphalt material present in the surface of the section (e.g., binder type and chemistry, aging level).
- Spray-on rejuvenators can slow the rate of pavement aging caused by oxidation.
  - Could potentially be applied every three years to prolong pavement life.
- The 1-month (four-week) aging time proposed in the FAA P-632 procedure can be misleading for assessment of a spray-on rejuvenator product’s long-term effectiveness.
  - ≈ 24 months of field aging was required to differentiate among products.

Next Steps

- To further monitor and evaluate the long-term performance of the applied products, and to capture the time interval where these products will lose effectiveness, the next field cores will be collected after
  - 42-month filed interval (05/16/2022)

Thank You

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