

## Executive Summary and Research Readiness Level Assessment

# Research on High-RAP Asphalt Mixtures with Rejuvenators – Phase II

### Research Objectives

The overall goal of Phase II was to investigate how high RAP mixtures and materials perform due to different applications (dosages and blending methods) of rejuvenators so that an optimum rejuvenating practice for our state can be developed. More specifically, the research team tested the different rejuvenators by changing their dosages applied to the typical mixture to determine optimum mixture designs with rejuvenators. The effects of rejuvenating procedures (e.g., treatment to RAP, treatment to entire mixture, or treatment to virgin binder, etc.) that are case specific was also investigated. This provided core information to reduce costs in mixture production without compromising mixture quality when high amounts of RAP are used.

### Research Benefits

Research findings significantly affected the asphalt pavement practice. Test results and findings were used to provide useful implementation guidelines of Nebraska asphalt mixtures containing higher amounts of RAP (up to 65%).

This research would also bring clear benefits in cost savings and sustainability by expanding the use of recycling materials into pavement engineering. It is also expected that the results of this research can contribute to maximize the use of RAP in Nebraska without compromising core engineering properties for long term pavement performance.

### Background

This study aimed to investigate the effects of type, dosage, and treating methods of rejuvenators when they are added in aged asphalt materials. To meet the goal, the research team used the three rejuvenators (R1, R2, and R3) by conducting various binder-level and mixture-level tests in this study. For the binder-level testing, the performance grading (PG) method was used to primarily determine proper dosages targeting desired binder grades, and two chemical tests (i.e., Fourier Transform Infrared and Saturates-Aromatics-Resins-Asphaltenes analysis) were also conducted to examine chemical characteristics altered by rejuvenation and further aging process. The selected dosage levels from the binder testing were then applied to asphalt concrete (AC) mixture-level performance evaluation by conducting two tests: flow number for rutting and semicircular bending fracture with and without moisture conditioning for cracking. AC mixtures treated with rejuvenators at the dosage levels selected from the binder PG testing showed improved fracture resistance compared to unrejuvenated mixtures.

### Conclusion

Test-analysis results indicated that PG binder testing, although it can successfully determine the proper dosage range of rejuvenators, is limited by only assessing the effects of rejuvenators in mechanical properties, which can be better aided by integrating chemical characterization that provides a more in-depth material-specific rejuvenation process. In addition, it appeared that rejuvenation methods (e.g., blending and/or curing) can alter performance of aged mixtures. Therefore, the selection of rejuvenators and their implementation into practice should be carried out by considering multiple aspects not only by its PG recovery.

### Principal Investigator

**Yong-Rak Kim (P.I.)**

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### Lead TAC Member

**Robert Rea, Asphalt and  
Quality Assurance Engineer**

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Interested in finding out more?

Final report is available at:

[NDOT Research Website](#)

### NDOT Recommendations Based Off of Research Project

The implementation for this project will continue under M115 Effect of Antioxidant Additives and Recycling Agents on Performance of Asphalt Binders and Mixtures – Phase II research project began in July 2019 and expected completion date of December 2021.

- As provided by Robert Rea, Lead TAC Member

### Technology Transfer

#### Transportation Research Record Journal Paper Published

- G. Nsengiyumva, H. F. Haghshenas, Y. Kim, and S. R. Kommidi. (2020). "Mechanical-Chemical Characterization of the Effects of Type, Dosage, and Treatment Methods of Rejuvenators in Aged Bituminous Materials." *Transportation Research Record*, 2674(3), 126-138.

#### Transportation Research Board Presentation

- "Effects of Type, Dosage, and Treating Methods of Rejuvenators in Aged Bituminous Materials: Mechanical-Chemical Characterization." *Presented at the 99th Transportation Research Board Annual Meeting, Washington, D.C., 2020.*

### Research Readiness Level (RRL) Assessment

#### Level 2: Applied Research/Proof Concept – Lab Level

-Research/Technology developed in a laboratory environment. Integration of components

**RRL 2**

**This brief summarizes Project SPR-P1 (18)– M070  
“Research on High-RAP Asphalt Mixtures with Rejuvenators – Phase II”  
Nebraska Department of Transportation Research Program**