Executive Summary Research Readiness Level Assessment and Technology Transfer

Evaluation of Mixtures and Pavement Performance for Rehabilitation Methods

Research Objectives

The overall goal of this research effort was to test several different mixtures and use mixture properties to investigate pavement performance and LCC analysis when they are used in different rehabilitation practices in Nebraska.

Research Benefits

Research findings advanced Nebraska's pavement engineering (design–rehabilitation–maintenance). It also enabled the more engineered use of local paving materials including recycling materials (RAP) and better-performing pavements.

Principal Investigator

Yong-Rak Kim (P.I.)
University of Nebraska

Lead TAC Member

Bruce Barrett,
Pavement Design Engineer

Background

About 75% of 3R pavement rehabilitation practices in Nebraska is by milling old 4&in. asphalt surface and placing a new 4&in. layer. Another 10% is a deeper replacement such as 5&in. mill/fill or 6&in. mill/fill. Traditionally, NDOT has used one mix for the 4-in. strategy; previously 4&in. of the SP4 mix, now 4&in. of the SPR mix. For deeper rehabilitation, NDOT has been using a combination of SRM with SPR or SLX. SRM usually allows 35–65% RAP (reclaimed asphalt pavement) with a coarser mix gradation so that high stiffness can be achieved.

To improve pavement engineering practices in Nebraska, there was a clear need to look into the feasibility and potential applications of overlay configurations with more economical mixes such as SRM in our state, and this requires research efforts to address several important questions, including (1) if the new layer configurations including SRM and/or SLX in pavements perform properly compared with the conventional 4&in. mill/fill by SPR, in particular, to resist cracking; (2) if the new layer configurations can save life cycle costs (LCC), and how much if so, compared with the conventional 4-in. mill/fill rehabilitation practice by SPR.

Conclusion

Pavement rehabilitation practice involves milling an asphalt surface and placing a new layer. The incorporation of reclaimed asphalt pavement (RAP) mixtures brings cost savings and preserves the environment and natural resources. However, the use of recycled materials can compromise pavement performance, in particular, RAP can induce more cracking because the mixtures with recycled materials become more brittle. In Nebraska, pavement rehabilitation has mostly been conducted by milling old 4-in. asphalt surface and placing a new 4-in. layer. Due to the potentially increased use of RAP mixtures for pavement rehabilitation, it is necessary to look into potential applications of RAP-induced overlay configurations that can save costs without compromising pavement performance.

Toward that end, this research project selected six overlay mixtures containing RAP in different qualities. Mixtures were tested to identify mechanical and fracture properties in low and intermediate temperatures. Using these mixture properties, the thermo-mechanical behavior of asphalt pavements was predicted by conducting finite element simulations incorporated with cohesive zone fracture for both thermal cracking and reflective cracking. A total of twelve overlay configurations (six cases with two different RAPs) were considered and compared. Pavement performance and predicted life from the finite element modeling were then used to conduct life cycle cost analyses (LCCA). LCCA results are expected to advance Nebraska's pavement engineering (design–rehabilitation–maintenance) by allowing a more informed use of local paving materials containing RAP.

Executive Summary Research Readiness Level Assessment and Technology Transfer

NDOT Recommendations Based Off of Research Project

- The purpose of this research was to compare the standard practice of milling 4" of existing asphalt and placing 4" of Asphaltic Concrete Type SPR with other asphalt mix combinations. One thought is the higher the savings from reduced binder as a result of increased RAP in the mix would create enough initial cost savings that using AC Type SRM would be the best alternative especially in the lower lifts. The concern with high RAP mixes is the potential for cracking, reduced longevity and increased maintenance cost. SRM allows up to 65% RAP though actual use is closer to 50% RAP and SPR typically averages about 40% RAP. As the percentage of RAP increases, the potential for cracking also increases. Increased cracking results in a shorter life with increased maintenance costs. Two RAP qualities were evaluated, those marked with a * are considered poor quality RAP. The service life was significantly less for poor quality RAP. Finite element simulations were used to predict the life of pavements and this information was used to conduct LCCAs. The results of the analysis clearly support the use of 4-inch SPR for rehabilitation purpose because of its lower maintenance frequency, lower need to major maintenance activity and longer service life. Table1. Shows the case analysis.

Table.1

Cases	Estimated Structural Life (in years)	Equivalent Uniform Annual Cost	Input for LCCA of rehabilitation practices for 45 years analysis period	
			Maintenance frequency (years)	Construction cost ($/1-mile)
4-inch SPR	22.33521	User- 7.16	5.5/11	228048.558
	16.41708*	Agency-11.86		
1.5-inch SPR + 2.5-inch SRM	19.04088	User- 7.21	5/10	216509.212
	14.70926*	Agency- 12.26		
1-inch SLX + 3-inch SRM	18.94948	User- 7.22	5/10	220967.736
	16.24067*	Agency -12.50		
2-inch SPR + 2-inch SRM	20.93204	User- 7.20	5/10	220729.981
	15.74872*	Agency-12.29		
2-inch SLX + 2-inch SRM	21.36648	User- 7.16	5/10	237723.767
	16.15283*	Agency- 12.22		
4-inch SLX	22.18101	User- 7.16	5.5/10	261671.330
	16.9965*	Agency- 12.98		

- *As provided by Bruce Barrett, Lead TAC Member*

Interested in finding out more?

Final report is available at:
NDOT Research Website

Executive Summary Research Readiness Level Assessment and Technology Transfer

Technology Transfer

Transportation Research Board (TRB) Papers

- M. Rahmani, A. Azzam, Y. Kim, and G. Nsengiyumva. (202X). "Effects of RAP on Pavement Performance Based on Mechanistic Performance Prediction Modeling and Data Analysis of Actual Field Performance." *Transportation Research Record*, submitted.

Research Readiness Level (RRL) Assessment

RRL 5

Level : Standard Practice

Research/Technology fully implemented and understood. No follow-up is necessary.

This brief summarizes Project SPR-P1 (18) M084
"Evaluation of Mixtures and Pavement Performance for Rehabilitation Methods"
Nebraska Department of Transportation Research Program