Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Nebraska Balanced Mix Design - Phase I

Research Objectives

The aim of this research is to establish benchmarks for the current and future mixture designs and criteria to address rutting, cracking, and moisture damage resistance in more detail, especially with a focus on high recycled mixtures and major binder modifications through the use of recycling agents and antioxidants. To this end, the BMD performance tests in high-, and mid-temperature used in different states will be considered and some of them will be carried out on various Nebraska mixtures collected from the field projects. In addition, moisture performance tests will be included in the Nebraska BMD. Long-term aging protocols will be applied to the mixtures to address cracking resistance more accurately. The field evaluation will be conducted on pavement sections and field data will be collected to establish pass/fail thresholds for future quality assurance and acceptance purposes. Then the mixtures containing recycled materials, recycling agents, and antioxidant will be designed and evaluated based on the established pass/fail thresholds.

Research Benefits

The results of this study will provide significant insights to the current and future mixture designs and criteria by addressing major pavement distresses like rutting, cracking, and moisture damage. A special focus will be given to high recycled mixtures modified by additives like recycling agents and antioxidants. The successful development and implementation of BMD in our state will provide safer, more efficient, trustworthy, and comfortable means for the transportation construction industry. It also can lead to significant cost reduction and provide longer lasting and more sustainable asphalt pavements.

Principal Investigator

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Background

Typically, asphalt mixtures are designed under the Superpave system, in which the proportioning of the aggregates and asphalt binder is based on the aggregate quality characteristics and mixture volumetric properties such as air voids, voids in the mineral aggregate, and voids filled with asphalt. Mixtures designed with high amount of asphalt can be susceptible to rutting, while those with low asphalt content are prone to cracking, raveling, or other durability related pavement distresses. One of the largest shortcomings of current design procedures is the lack of long-term materials aging protocol. Therefore, performance tests should be included as part of the mixture design procedure to ensure the desirable field pavement performance. Many performance tests have been proposed for the evaluation of the rutting resistance (e.g., Hamburg Wheel Track Tester, Gyratory Stability, IDEAL Rutting Test, and High-Temp Indirect Tensile Test), cracking resistance (e.g., Semi-circular Bending Test and IDELA Cracking Test, and moisture susceptibility (e.g., Indirect Tensile Strength, Hamburg Wheel Track Tester) of the asphalt mixtures. In Balanced Mix Design (BMD), two or more mechanical tests are coupled to quantify the mixture resistance against different forms of distress.

Conclusion

Balanced mix design (BMD) is an alternative concept for designing asphalt mixtures that mainly focuses on performance of mixtures rather than only volumetric analysis. Using this concept, it would be possible to account for the incorporation of recycled asphalt mixtures, warm technology, polymers, rejuvenators, and other foreign additives, as well as external effective factors on the mix design such as environmental effects. This project sought to investigate performance-based methodologies for the asphalt mix design by taking a step to develop a preliminary Nebraska BMD framework. With that, selection of appropriate performance tests, finding a functional laboratory aging protocol, and defining performance test criteria were the main long-term goals developed in this phase of study. To this end, three main types of distresses were taken into consideration (rutting, fatigue cracking, and moisture susceptibility), and a set of performance tests including well-established tests (Hamburg Wheel Track (HWT), Illinois Flexibility Index Test (I-FIT), Tensile Strength Ration (TSR)) and surrogate tests (IDEAL-RT, HT-IDT, G-stability, IDEAL-CT) were selected to capture these distresses on two types of high-performance commonly used asphalt mixtures in Nebraska (SLX and SPR). For the fatigue cracking analysis, long-term aging conditioning was conducted using two common aging protocols (NCHRP 09-54 and NCAT). Three types of data were utilized in this study including laboratory performance test results for the lab-compacted and field core specimens, as well as field data based on pavement surface condition monitoring. The validity of the surrogate performance tests was accomplished not only by correlating the field core results with field condition data, but also with correlating every individual surrogate test result to that of a well-established test. Further, the sensitivity, practicality, cost-effectiveness, and variability of different tests were assessed using statistical analysis and review efforts. In terms of rutting and fatigue cracking, IDEAL-RT and IDEAL-CT tests showed the highest correlation to well-established tests as well as significant sensitivity and accuracy in terms of results. For the moisture damage resistance tests, no strong correlation was found between well-established and surrogate tests, except for the G-stability test that showed some potential to be considered for future studies. In terms of long-term aging methods, the NCAT protocol was found to be more severe than NCHRP 09-54, however, selecting an appropriate long-term aging protocol for the Nebraska BMD will be done after long-term data analysis in the next phases of this study. Finally, an initial understanding of each test's pass/fail criteria was achieved based on the test result values obtained from historically acceptable asphalt mix design in the state.

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NDOT Recommendations Based Off Research Project

This research project will ultimately define the Nebraska BMD method which considers 3 main distresses: rutting, fatigue cracking, moisture damage. To be able to fully implement the outcomes of this research, the field evaluation must be conducted, and field data must be collected to establish pass/fail thresholds for future quality assurance (QA) and acceptance (QC) purposes. The findings of this research will be used to establish pass/fail thresholds for BMD mix design method which is currently in progress. This will ultimately improve Nebraska's pavement engineering: materials, design, and maintenance. The successful development and implementation of BMD along with pass/fail thresholds in our state will provide safer means for the transportation construction industry and can bring significant cost savings and provide more sustainable asphalt pavements.

This research is Phase I with the follow-up project FY23(016) Nebraska Balanced Mix Design – Phase II, starting July 2022.

- *As provided by Bob Rea, Lead TAC Member*

Research Readiness Level (RRL) Assessment

Level: Applied Research/Proof of Concept/Lab-Level

RRL 2

Technology Transfer

Principal Investigator did not have any technology transfer for this research project.

This brief summarizes Project SPR-FY22(002)
"Nebraska Balanced Mix Design - Phase I"
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