Executive Summary, Research Readiness Level Assessment and Technology Transfer

Feasibility and Implementation of Balanced Mix Design in Nebraska

Research Objectives

The overall goal of this research effort was to examine the feasibility of the BMD approach for Nebraska pavements and to develop a potential implementation plan of the method if it appears feasible.

Research Benefits

Research findings improved Nebraska's pavement engineering (both materials and pavement design). It also enabled the more engineered use of local paving materials and better performing pavements due to the addition of a performance-based concept into the mixture design process. Successful accomplishment of this research thus brings cost savings due to more optimized use of materials and less long-term performance maintenance.

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Background

Balanced mix design (BMD) is an alternative mix design that incorporates two or more mechanical performance tests, such as a rutting test and a cracking test, to assess how well the mixture resists common forms of distress. The BMD is considered as overcoming several issues in the current Superpave volumetric mix design, where proportioning of the aggregates and the asphalt binder relies primarily on empirical aggregate quality characteristics and mixture volumetric properties. Calculation of the volumetric properties is highly dependent on an accurate determination of the specific gravity of the mix components, which is not easy nor accurate with current test methods. Furthermore, the complexity and inaccuracy increase with the incorporation of reclaimed asphalt pavements (RAP) and foreign additives such as warm-mix additives, polymers, rejuvenators, and fibers. Therefore, performance tests needed to be included as part of the mix design procedure to help ensure desirable pavement performance in the field.

Conclusion

Balance mixture design (BMD) is an alternative asphalt concrete (AC) design method which incorporated the performance of mixtures during the design. BMD thus consisted of performance test methods and performance criteria. Compared to the existing Superpave design method which mostly relies on volumetrics to design mixtures, BMD is more suited to account for performance improvements originating from RAP (reclaimed asphalt pavement) and other foreign additives such as rejuvenators, WMA (warm-mix asphalt) additives, polymers, and anti-stripping agents. This study investigated the feasibility of implementation of BMD in Nebraska mixtures by exploring appropriate test methods (i.e., for fracture and rutting) and method of selection of performance criteria. For the fracture test, the semicircular bend (SCB) test method was selected and investigated for the appropriate testing conditions that can provide repeatable results. These testing conditions included: the number of replicates, specimen thickness, testing temperature, notch length, and loading rate. Also, the effect of the SCB testing configurations on the test results and their repeatability was explored. For the rutting performance test, a simple rutting test called G-Stability was explored by determining critical testing conditions that can aid repeatable results and practical implementation. Validity of the newly developed G-Stability test was accomplished by correlating its test results to that of the established FN (flow number) test. The correlation showed interchangeability between the G-Stability and the FN, which demonstrated the feasibility of the G-Stability as a rutting performance test. Finally, the two performance tests (SCB and G-Stability) were conducted for typical Nebraska AC mixtures and several high-RAP mixtures. Test results were incorporated with a performance space diagram (PSD) to apply the BMD concept.

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NDOT Recommendations Based Off of Research Project

This research was a feasibility study. The results showed that it is feasible to implement a Balance Mix Design System. Additional evaluation in being conducted in Phase II Research on High-RAP Mixtures with Rejuvenators - Field Implementation.
Phase II is to benchmark the current mix designs in Nebraska. The effort is to test field produced mixes and further assess its applicability and implementation into the quality assurance (QA) and quality control (QC) acceptance testing system. The Department estimates that it will take 2 years until this concept can be implemented into a pilot research test section.

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

Research Readiness Level (RRL) Assessment

RRL 2

Level 2: Applied Research/Proof Concept – Lab Level

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

Technology Transfer

Transportation Research Board (TRB) Papers and Publications

- 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.
- G. Nsengiyumva and Y. Kim. (2019). "Effect of Testing Configuration in Semi-Circular Bending Fracture of Asphalt Mixtures: Experiments and Statistical Analyses." Transportation Research Record, DOI: 10.1177/0361198119839343.

Transportation Research Board Presentations

- "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.
- "Effect of Testing Configuration in Semi-circular Bending Fracture of Asphalt Mixtures: Experiments and Statistical Analyses." Presented at the 98th Transportation Research Board Annual Meeting, Washington, D.C., 2019.

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