Executive Summary and Implementation

Development of DSR Test Method to Determine Binder Low Temperature Properties

Research Objectives

An alternative testing analysis method using the DSR to determine low temperature asphalt binder properties that have been measured by the BBR. More specifically, the research team developed a DSR testing analysis method and resulting material parameters to supplement (or potentially replace) the BBR approach, which will be based on scientific comparison correlation of test results between the two methods. The research team tested multiple binders used in Nebraska to reach general conclusions.

The expectation that the alternative testing analysis method could serve a useful tool for screening binders before performing entire BBR tests, or possibly replace the current BBR testing protocol for low temperature examination of binders.

Research Benefits

Multiple benefits to asphalt pavement engineering:

- Cost savings;
- Work efficiency; and
- Wider application of the technique to field materials.

One equipment (i.e., DSR) characterized the entire binder properties in all temperatures, which clearly saved costs and time to conduct quality assurance testing of binders.

Ultimately, this research contributed to a more engineered and economical implementation of paving materials in Nebraska by providing crucial information and scientific insights.

Background

The low temperature rheology of bituminous binders is of great interest because low temperature cracking is one of the primary asphalt pavement failure modes observed in cold-climate places such as Nebraska. Low temperature binder characterization/grading has been primarily conducted using the bending beam rheometer (BBR), while the dynamic shear rheometer (DSR) can alternatively be used to characterize the low temperature properties of binders with the recent advancement of DSR equipment that can cover a wide range of testing temperatures. This study investigated alternative testing-analysis methods using the DSR to determine low temperature asphalt binder properties that have been measured by the BBR. Toward that end, twelve different binders from four sources satisfying three different PG grading criterion common in Nebraska were selected. The binder samples were tested in the frequency domain at temperatures ranging from 60°C to -30°C under PAV-aged conditions using DSR. The 8-mm parallel plate geometry was primarily employed for the testing, while four binders were randomly selected and tested using the 4-mm parallel plate to investigate the influence of geometry on the results. BBR experiments were also performed as a parallel for each binder.

Conclusion

Three methods were used to analyze and compare the data from the two different experiments (i.e., DSR and BBR) where each method utilizes a different scheme for converting the frequency domain results to time domain data to compare with the BBR results. The three methods are: (1) Western Research Institute's (WRI) methodology; (2) NCHRP methodology; and (3) UNL's mechanistic approach. It was observed that the DSR testing is quite promising, and sample preparation is crucial to obtain reliable-repeatable results. Moreover, in the proposed UNL's mechanistic approach, it was observed that a single shift factor for creep compliance may account for different testing conditions, differences in physical hardening and temperature-dependent effects. The approach was then extended to seven additional binders to further examine its feasibility, and it was observed that the predictions from the proposed approach match well with the experimental values.

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Final report is available at:
NDOT Research Website

Recommendations for Implementation

This research will bring a great opportunity for the NDOT to enable the binder testing program, in a much more efficient manner, by reducing (or possibly eliminating) the time consuming and laborious BBR tests. The new low temperature binder test method and resulting material parameter(s) can be implemented into the NDOT binder testing program and relevant specifications.

This new test method will be performed in-house to determine binder low temperature properties. The testing will begin in December 2020.

Technology Transfer

Construction and Building Materials (CBM) Journal Paper Revised for Publication

- S. R. Kommidi and Y. Kim. (202X). "Dynamic Shear Rheometer Testing and Mechanistic Conversion to Predict Bending Beam Rheometer Low Temperature Behavior of Bituminous Binder." *Construction and Building Materials*, revision submitted.

Transportation Research Board Presentation (TRB)

- "DSR Testing and Mechanical Analysis to Predict BBR Low Temperature Behavior of Asphalt Binder." *Presented at the 99th Transportation Research Board Annual Meeting*, Washington, D.C., 2020.

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