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New Jersey Department of Transportation
Bureau of Research

Technical Brief

Correlation between Multiple Stress Creep Recovery (MSCR) Results and Polymer Modification of Binder

The New Jersey Department of Transportation would like to expand its use of polymer modified binder, however, current Superpave PG plus testing is time intensive and expensive. Multiple Stress Creep and Recovery Test (MSCR) is a relatively new test that could be used. Its use could open the state to a larger market of modified binders.

Background

Nationwide traffic loads are increasing, pushing conventional asphalt to its limit. In New Jersey matters are made worse by the heavy use of the Northeast Corridor. Polymer modification of asphalt, which can improve both low and high performance, is already available; however, in many cases traditional Superpave testing is not sensitive enough to quantify the impact of modification, dimensioning its use.

Elastic Recovery and Forced Ductility, Superpave Performance Grade Plus tests, are sensitive to polymer modification but are time intensive and costly. These obstacles have lead the New Jersey Department of Transportation to require styrene-butadiene or styrene-butadiene-styrene to be incorporated in all modified binder to ensure performance, causing supply shortages and rising cost in the state. A relatively new test developed by the Federal Highway Administration, Multiple Stress Creep Compliance (MSCR) offers a simpler procedure using the Dynamic Shear Rheometer (DSR), thus it does not require the expense of purchase additional testing equipment.

Research Objectives and Approach

The main objectives of the study are:

- To verify and qualify the MSCR parameter, non-recoverable compliance J_{nr}, as a standard measure of modified binder performance
- Conduct traditional Superpave binder tests (AASHTO M 320 Table 1), Superpave PG Plus testing Elastic Recovery and Forced Ductility, to be compared to the non-recoverable creep compliance parameter J_{nr}.
- Perform performance testing to link the non-recoverable creep compliance parameter J_{nr} to performance.
- Develop a Microsoft access database of binder and mix data so that the state of New Jersey can select appropriate binders and mixtures that can meet the target values.

Findings

The following conclusions were made based off of results found in this report:

- MSCR binder testing is sensitive to asphalt mix performance. Binders with non-recoverable compliance value (J_{nr}) of less than 0.5 kPa^{-1} appear to show better high temperature performance. The results are in line with the AASHTO MP 19-10 specification. It should be noted that the scope of this study was limited to binder selection and many other parameters impact the performance of roadways.
- The MSCR elastic curve requirement appears to be the most stringent of the requirements to evaluate elastic response as compared to elastic recovery at 25ºC and phase angle of 75.
- An MSCR recovery at 3.2kPa greater than 40% will ensure that it is above the MSCR elastic recovery curve. This could serve as an alternative specification to the MSCR elastic recovery curve.

- Additional linear and non-linear viscoelastic binder properties can be determined from the analysis of the MSCR curve. These provide invaluable in-sight into how the polymer modification influences different types of mechanical responses.
- Some modified binders with a lower PG-grade (-28 versus -22) may grade high on the AASHTO MP-19, which could be misleading that they can withstand heavy traffic.
- Using the MSCR parameter in the binder specification will have the potential to allow the state to open the market to abroad range of modified binders.
- The MSCR test for non-recoverable creep compliance (J_{nr}) is a simple and quick test to perform and does not require the purchase of an additional testing apparatus since it uses the Dynamic Shear Rheometer (DSR), which is already a common piece of lab equipment in the asphalt industry. Current test method such as Elastic Recovery (ER) and Force Ductility (FD) are time intensive and require the purchasing of additional testing apparatus and are not necessary to evaluate polymer modified binders.

Recommendations

The following are the recommendations from the study:

- MSCR testing using the parameter J_{nr}, should become a standard means to evaluate polymer modified binders in New Jersey. The guidelines set forth by AASHTO MP 19-10, in which the binders are graded according to traffic (ESALs) by using J_{nr} is recommended.
- The New Jersey DOT should use the access database system as a prescreening process for binder selection, alleviating extraneous binder testing and the cost associated with them.
- New Jersey DOT could eliminate the use of elastic recovery, thus saving almost $15,000 dollars on capital cost of equipment and up to $500 per binder characterization considering labor and depreciation cost. These could lead to considerable savings of thousands of dollars over several years.
- Additional testing, including field performance should be conducted on binders with low J_{nr} (less than 0.5 kPa^{-1}) and with a lower PG-grade, such as PG 64-28 versus PG64-22.
- This can be addressed by closely looking at the ODSR result of binders. For example, at 64˚C, if the G*/sin(δ) is below 2.0 kPa, it is unlikely to pass a higher grade and withstand heavy traffic.
- Low non-recoverable creep compliance (J_{nr} < 0.5 kPa^{-1}) coupled with high MSCR recovery at 3.2 kPa (recovery greater than 40%) and G*/sin(δ) high enough to pass the next high grade will ensure that the binder selected will withstand heavy and extreme traffic levels.
- Most of the binders provided by the refinery do not have specific compositions. Some binders may have several polymers meeting the target specifications. Therefore, it is not known how other polymers influence the non-recoverable compliance. A detailed evaluation of the impact of a broad range of polymer modification on the non-recoverable compliance is needed. However, appropriate interlocking should be evaluated using direct measurement tools, such as the fluorescent microscope.

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A final report is available online at: http://www.state.nj.us/transportation/refdata/research/. If you would like a copy of the full report, send an e-mail to: Research.Bureau@dot.state.nj.us.

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