LTRC Technical Summary Report 444

LTRC Proj. No. 08-2P ~ State Proj. No. 736-99-1519

June 2009

Louisiana Transportation Research Center

4101 Gourrier Ave., Baton Rouge, LA 70808

Analysis of Seasonal Strain Measurements in Asphalt Materials under Accelerated Pavement Testing and Comparing Field Performance and Laboratory Measured Binder Tension Properties

Introduction

Since 1996, the Louisiana Department of Transportation and Development (LADOTD) has utilized the Louisiana Transportation and Research Center's (LTRC's) Accelerated Loading Facility (ALF) at the Pavement Research Facility to determine the effectiveness of innovative pavement technologies in an environment closely resembling actual in-service field conditions. However, the seasonal variation of measured pavement responses with temperature and its relationship to predicted performance has not been thoroughly evaluated in past ALF experiments. Such information may be used to improve instrumentation strategies in future ALF experiments and to determine the evolution of damage with an increase in the number of repetitions. Results of past ALF experiments may also be used to link laboratory measured properties of asphalt binders to the measured performance of hot mix asphalt (HMA). Such a link may be used to update current binder standards by specifying measurements of properties that are indicative of pavement performance.

Objective

The objectives of this study were twofold. First, instrument responses in past ALF experiments were analyzed to quantify the variation of pavement responses with temperature, repeatability of stress and strain measurements, and the use of sensors technology to assess the evolution of pavement damage. Second, the relationship between binder deformation properties at intermediate and low temperatures and mix performance was established.

Scope

The first objective of this study was achieved by reviewing and analyzing collected instrument responses from ALF Experiments II and III and quantifying the impacts of temperature variations on instrument responses and on the measured pavement performance. The second objective of this study was achieved by testing nine straight binders obtained from two asphalt suppliers using the ductility test at intermediate temperatures, the direct tensile test at low temperatures, and multiple stress creep recovery using the dynamic shear rheometer. To assess the results of these tests, selected asphalt binders were also evaluated using high pressure gel permeation chromatography (HPGPC), dynamic mechanical analysis (DMA), and differential scanning calorimetry (DSC). To relate binder properties to mix performance, three of the nine binders with contrasting levels of ductility were used to prepare hot mix asphalt specimens, which were tested using the indirect tensile strength test.

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Principal Investigator:

Mostafa Elseifi, Ph.D.

LTRC Contact:

Zhongjie "Doc" Zhang, Ph.D., P.E.
Phone: (225) 767-9106

Louisiana Transportation Research Center

Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

4101 Gourrier Avenue
Baton Rouge, LA 70808-4443

www.ltrc.lsu.edu

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Methodology

To achieve the objectives of this research study, the following tasks were performed:

- Reviewed and analyzed collected instrument responses from Experiments II and III and quantified the impacts of temperature variations on instrument responses and pavement performance.
- Developed an instrumentation plan for the upcoming Experiment V.
- Conducted a ductility test on the sampled asphalt binders.
- Conducted direct tensile and multiple-stress creep recovery tests on sampled binders and compared the ranking obtained from this test to the prediction obtained from conventional tests (i.e., ductility). Repeatability of these tests was also established.
- Prepared hot mix asphalt specimens using the indirect tensile strength test and related these measurements to the binder properties at intermediate and low temperatures.
- Prepared final report that documents and summarizes the study findings and results.

Conclusions

Based on the results of this study, the following conclusions were drawn:

- Repeatability of stress and strain measurements was acceptable in most cases. Survivability of the gages was also deemed acceptable. However, installed pressure cells in the granular layers appeared to tilt during construction or after loading began, possibly due to poor compaction of the supportive layer.
- Pavement responses were strongly influenced by temperature during testing. An exponentional model provided an acceptable description of this variation.
- Strain gages were not a reliable indicator of damage development in HMA. It appeared that with an increase in the number of passes, strain gages dispersed the material around them, resulting in less contact with the surrounding medium; therefore, a smaller strain was measured.
- Measured vertical stress remained fairly constant with an increase in the number of passes. This observation indicates that the stress applied on the material mainly depends on the magnitude of the external load and not on the level of damage in the material.

Recommendations

A detailed instrumentation plan for future ALF experiments was provided as a result of this research project. This plan calls for a number of modifications to past instrumentation strategies. This includes intensifying measurements in the early stage of the experiment, using temperature sensors such as thermocouples, increasing the distance between sensors in the longitudinal direction, and improving the compaction of pressure gages.

In addition, the measurement of binder ductility is beneficial to the state and correlates well with mix performance at intermediate temperatures. This test may not be substituted with the direct tensile test or the multiple stress creep recovery test.