Louisiana Transportation Research Center

Technical Summary Report 374

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Comparative Performance of Rubber Modified Hot Mix Asphalt Under ALF Loading

Introduction

Waste or scrap tires pose a substantial waste management challenge due to the large number of scrap tires generated annually throughout the nation. In order to reduce scrap tire inventories, applications and markets for scrap tire rubber have to be developed and enhanced. In 1991, the Intermodal Surface Transportation Efficiency Act (ISTEA) specified that any asphalt pavement project funded by federal agencies must contain a certain percentage of scrap tire rubber. Although this mandate was later rescinded, it did encourage the research and application of hot mix asphalt (HMA) materials that include crumb rubber modifier (CRM) in pavement construction. CRM has been used in asphalt pavement construction for over 40 years, principally as local patch repair material, as interlayers, or in seal coat construction.

One of the principal unresolved issues regarding the use of recycled rubber in asphalt pavement is the actual field performance of the material. When material characterizations from laboratory testing have been used in computer models such as VESYS, the models have generally predicted better performance for the CRM-HMA than has been observed in the field. A field study was necessary to evaluate the performance of HMA materials that include CRM because of the need to evaluate the engineering benefits of using CRM, to determine their optimal position within the pavement structures, to dispose of tires in an economical fashion, and to determine the appropriate structural coefficient for use in pavement thickness design. Full-scale testing using the Accelerated Loading Facility (ALF) provided the best alternative for a relatively quick assessment of the cost-effectiveness of CRM-HMA.

Objectives and Scope

The objectives of this study were to evaluate the overall performance under accelerated loading of hot mix asphalt mixtures containing powdered rubber modifier (PRM) as compared to similar mixes with conventional HMA and to optimize the use of these materials in the pavement structure. Additionally, the determination of an appropriate structural coefficient (a-value) for use of these materials in the structural design of flexible pavements using the AASHTO design procedure was required.

To achieve these objectives, three test lanes were constructed at the LTRC Pavement Research Facility (PRF) using conventional and rubberized HMA. Loads were applied and field performance data were collected until failure occurred using the selected

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failure criteria. The second part of this study involved conducting numerical simulation of test lanes using two finite element programs: FLEX-PASS and ABAQUS.

Research Approach

The project consisted of construction, field loading and testing, laboratory characterization, and numerical simulation of the three test lanes at the Louisiana Pavement Research Facility under accelerated loading. The experiments were designed so that comparisons could be made between powdered rubber-modified HMA and conventional HMA in the surface and base.

Three test lanes were constructed at the PRF: one with conventional mixtures, one with a PRM-HMA Type 8 wearing course, and one with a PRM-HMA base course as shown in table 1. The conventional materials used in wearing and binder courses in Louisiana consist of an HMA with a binder to which a three percent polymer has been added.

To simulate highway traffic, the loads were applied only in one direction and were normally distributed along a 32-inch (813-mm) wheel path. The magnitude of the loading varied with the number of loading plates. At the beginning of the test, a 9.75-kip (43-kN) load was applied through dual-tires with tire pressure maintained at 105 psi (724 kPa). The initial 9.75-kip (43-kN) load was applied and, then, was increased in increments of 2,300 pounds (10.2 kN) at the same tire pressure until the completion of accelerated loading tests. The total traffic applied to test lanes 2-1 and 2-3 was 800,000 passes while lane 2-2 received 850,000 passes. The results of the loading and the rut depth measurements are shown in figure 1.

For numerical simulation and pavement modeling, the input parameters for FLEXPASS were based on the results from laboratory tests performed on pavement materials from the ALF site and field information. The predicted performance includes rutting, fatigue cracking, slope variance, and present serviceability index (PSI). A three-dimensional dynamic finite element analysis was used in this study to calculate the primary responses (stress and strain) of the pavement to the applied loads. The input parameters for ABAQUS were developed from laboratory testing, and the predicted pavement responses were compared to experimental measurements made on ALF test sections.

Field measurements included the periodic collection of cracking, transverse and longitudinal profiles, deflection data, and temperatures. Deflection testing was conducted on a periodic basis using the falling weight deflectometer (FWD) and the Dynaflect. Each of the lanes had transverse profile measurements after each increment of 25,000 load applications.

Conclusions and Recommendations

Based on the findings of this study, the following conclusions and recommendations are presented:

- Powdered rubber or polymers should be added to AC-30 to form the binders used in asphalt bases. The resulting structural coefficient (a-value) for the powdered rubber base is 0.45 compared to 0.40 for a conventional base course using AC-30. Addition of the powdered rubber increases the cost of the binder only 10 percent while increasing its structural coefficient 12.5 percent.
- FLEXPASS can be used to successfully model Louisiana flexible pavements. All three of the test lanes exhibited agreement between the FLEXPASS-predicted rutting and observed field.
- ABAQUS can be used to calculate the primary responses and deflections not only from ALF loads but also from the loads applied by both the Dynaflect and Falling Weight Deflectometer.
- The superior performance of the three test lanes proves again the efficiency of a pavement section with an interlayer, where a stiff layer of soil cement is covered with a layer of stone, having a combination of asphalt base, asphalt binder, and asphalt wearing courses. This pavement section is very strong, experiencing rutting primarily in the wearing and binder courses with no reflection cracking from the soil cement layer during the two-year observation.
- The use of polymer or powder rubber-modified asphalt in all hot mix pavement layers is recommended along with the continued use of a granular base interlayer between the soil cement base and asphalt layers.

Table 1
Structure of test lanes

Lane 2-1	Lane 2-2	Lane 2-3[1]
1.5”(38 mm) Type 8F Wearing Course (PRM Wet Rouse Binder)	1.5” (38 mm) Type 8F Wearing Course (PAC 40 Binder)	1.5” (38 mm) Type 8F Wearing Course (PAC 40 Binder)
2.0” (51 mm) Type 8 Binder Course (PAC 40 Binder)	2.0” (51 mm) Type 8 Binder Course (PAC 40 Binder)	2.0” (51 mm) Type 8 Binder Course (PAC 40 Binder)
3.5” (89 mm) Base Course (AC 30 Binder)	3.5” (89 mm) Base Course (PRM Wet Rouse Binder)	3.5” (89 mm) Base Course (AC 30 Binder)
8.5” (216 mm) Crushed Stone	8.5” (216 mm) Crushed Stone	8.5” (216 mm) Crushed Stone
10.0” (254 mm) Soil Cement	10.0” (254 mm) Soil Cement	10.0” (254 mm) Soil Cement
38.0” (965 mm) Select Soil / Embankment	38.0” (965 mm) Select Soil / Embankment	38.0” (965 mm) Select Soil / Embankment

[1]Lane 2-3 is the control lane with conventional materials where the wearing and binder courses include a polymer-modified asphalt.

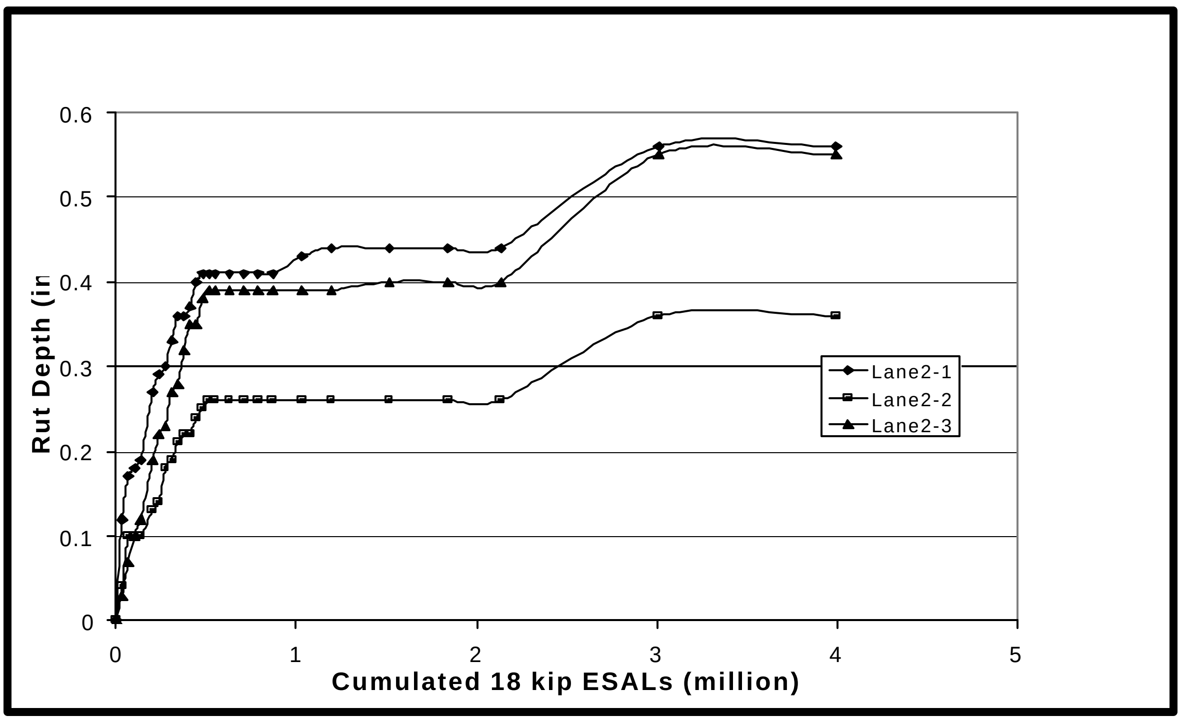

Figure 1
Observed rut depth versus cumulative 18 kip (80kN) ESALs for test lanes