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Project Summary Report 1814-S
Project 0-1814: MLS Research Management System - Phase II
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PROJECT SUMMARY REPORT

Accelerated Pavement Testing Near Jacksboro on US 281: Pavement Engineering Benefits

What We Did...

Pavements are complex structures, and some pavement engineering problems don't lend themselves to straightforward theoretical solutions. An example would be the performance of a surface rehabilitation treatment of a composite asphalt concrete (AC) pavement structure. The problem becomes even more difficult if lightweight aggregate asphalt concrete (LWAC) is involved or if surface water resulting from rain has to be taken into account. In the same vein, the temperature of the pavement during trafficking is a complicating factor.

It is precisely such problems that were studied by the Texas Department of Transportation (TxDOT) in the accelerated pavement testing (APT) program undertaken on US 281 near Jacksboro, Texas. The Texas Mobile Load Simulator (MLS) and the one-third-scale Model Mobile Load Simulator (MMLS3) were the primary tools for successfully exploring these problems. In the process, a number of spin-off findings have been gained, resulting in enhanced pavement engineering knowledge and a variety of lessons learned.

The success of the program is in no small measure due to the willingness of TxDOT's Pavements Section to allow the problem to be investigated systematically, through diagnostic studies using a wide array of ancillary tools.

Accelerated trafficking

- Three MLS tests that were completed in successive years during essentially the same seasons involved a total application of more than 2.8 million, 76 kN axle loads.
- Two tests were performed to compare Remixer and Dustrol rehabilitation strategies. The third test was a replication of the Dustrol test with tire pressure increased to 750 kPa.
- The MMLS3 was used to study the effect of surface water and increased temperature. Eight MMLS3 tests were completed involving more than 3.6 million axle loads.

The two primary APT devices have the following attributes:

The MLS as an APT tool

The Texas Mobile Load Simulator is operated nominally at 18 kph and can achieve an average of 6,000 axle repetitions per hour with a load frequency of ~3 Hz. It has six full, standard tandem axles that travel in one direction. The standard test procedure uses legal tandem axle loads of 152 kN with 76 kN on each of two tandem axles. There are a total of forty-eight tires, each normally inflated to 690 kPa. The MLS is nominally 31 m long, 6 m tall, and 4.5 m wide. Figure 1 shows a typical test layout. The field setup in the northbound section is shown in Figure 2. The MMLS3 wet test is underway in the foreground and the MLS is shown in the background.

The MMLS3 as an APT tool

The one-third-scale MMLS3 is a low-cost APT device that applies a maximum of 7,200 single-wheel load applications of 2.1 kN per hour. It is a unidirectional, scaled-down vehicle-load simulator for accelerated trafficking of model or full-scale dry and wet pavements in the field and in the laboratory. It has pneumatic tires normally inflated to 690 kPa. The temperature during trafficking can be controlled by placing it in a temperature chamber. Trafficking speed is up to 2.5 m/s (9 kph) or 27 kph simulated, which is equivalent to a frequency of about 4 Hz.

Field measurements and diagnostic tests with the MLS

- Climatic conditions during testing
- Falling weight deflectometer (FWD)
- Elastic transient deflection through multidepth deflectometer (MDD)
- Seismic wave propagation in the pavement layers as measured by
  - Spectral analysis of surface waves (SASW) (manual)
  - Full-depth SASW using the Seismic Pavement Analyzer (SPA) (automated)
  - Portable Seismic Pavement Analyzer (PSPA) (manual)
- Layer deformation by MDD
- Cracking patterns
- Transverse and longitudinal rutting profiles
- Dynamic Cone Penetrometer (DCP)
- Ground-penetrating radar (GPR)

Laboratory tests on cores from MLS test pads

- Repetitive triaxial tests
- Volumetric analysis (voids, gradation, specific gravity)
- Hamburg wheel-tracking tests

Field measurements and diagnostic tests with the MMLS3

- Test temperatures
- Seismic wave propagation measured by
  - SASW (manual)
  - PSPA (manual)
- Layer deformation using linear displacement pins (LDPs)
- Cracking patterns
- Transverse Rutting Profiles

Laboratory tests on cores from the MMLS3 test pads

- Indirect tensile fatigue tests
- Indirect tensile strength (before and after moisture conditioning) (ITS)
- Semi-circular bending tests (SCB)
- Volumetric analysis (voids, gradation, specific gravity)
- Shear and elastic stiffness and phase angle at different temperatures and load frequencies (G* E & δ).

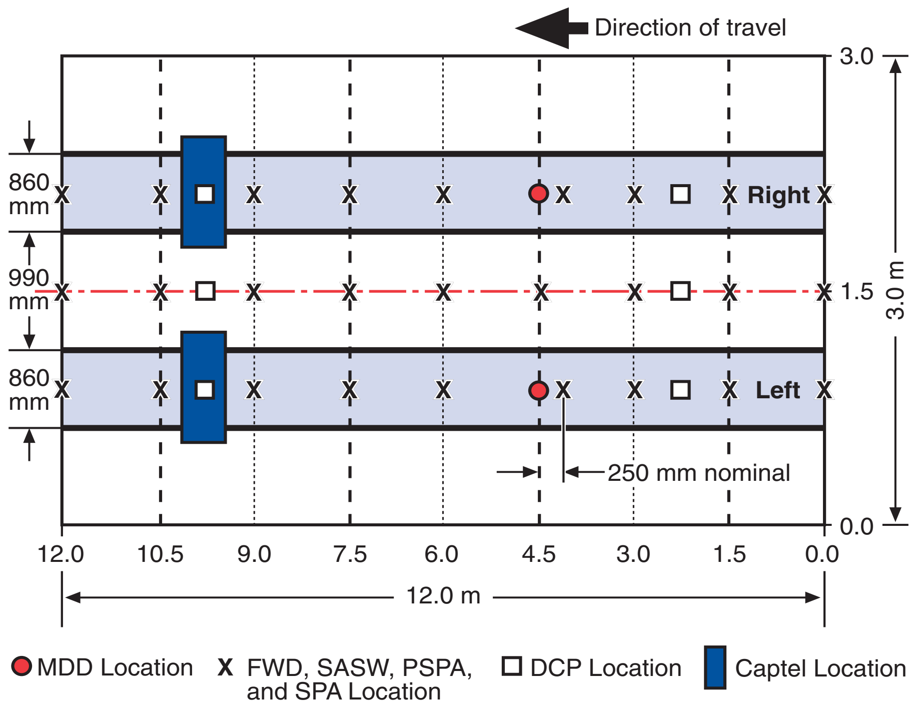

Figure 1: General MLS Test Layout

What We Found...

Field performance under MLS trafficking

The rutting in MLS tests fell below the limits specified for a highway. Nevertheless, there was a distinct difference between the two rehabilitation processes. At face value the difference was very pronounced (5 to 1). This difference had to be evaluated in terms of the different conditions prevailing during each test. The evaluation involved MMLS3 testing and analytical modeling. No load cracking occurred.

Performance under MMLS3 trafficking

With the wet and heated trafficking under the MMLS3, the results were much more definitive.

- Wet trafficking had a profound effect on the performance of both processes, primarily because of the underlying in situ untreated LWAC. The major cause of distress was not rutting, but a reduction in the indirect tensile fatigue life. The two processes would have essentially the same life expectancy if water could access the LWAC layer during trafficking.
- Under controlled, heated trafficking, the Remixer was more rut resistant than the Dustrol. With the limited trafficking, ruts in the northbound test pads were about 3 times greater than ruts in the southbound test pads. With the MLS, the uncorrected difference was five times greater.

Rut modeling with VESYS

The test data provided a unique opportunity to put the mechanistic VESYS rutting model rutting to trial. Input parameters α and μ for the VESYS program were obtained from repetitive triaxial tests at different temperatures (20 ˚C and 40 ˚C). With assumptions about weather seasons, VESYS3AM was used to predict the rutting. Modifications of α and μ values were needed to match field measurements through several trial runs.

The rutting in each individual layer was computed using the measured values for calibration. The model was then used to predict the remaining life of 281 S1 and 281 N1. To determine the effectiveness of the two processes, the same set of input parameters for the underlying layers was used with each of the surfacing layers. The Remixer process was always found to be superior to the Dustrol process.

Quantitative evaluation and analysis of MLS rutting

The quantitative analysis of the rutting performance is based on the assumption that the rut depth is determined by the cumulative effects of five factors that occur concurrently:

- temperature (F_t)
- structural response (F_s)
- material compliance after processing (F_m)
- wheel load (F_l)
- tire pressure (F_{tp})

where:

Total Affected Rut(s)=

$$\alpha\left(F_t^{\beta_t} \bullet F_s^{\beta_s} \bullet F_m^{\beta_m} \bullet F_l^{\beta_l} \bullet F_{tp}^{\beta_{tp}}\right)BR$$

where *BR* is defined as the *benchmark* rut, and *a* and *b* are regression factors.

Ruts in the different wheelpaths were compared in terms of a benchmark pavement lane. The wheelpath with the least rutting was usually selected as the benchmark lane.

For simplicity, the α and β factors were initially set to equal 1. With the results from the increased tire pressure tests, it was found that the structural response was overemphasized, and β was changed to 0.5. This value satisfied the equation.

Figure 2 Overview of the two APT Devices

From the data of the three independent MLS tests, the model appears to be sound. It gave reasonable results on the origin of the rutting and, with the increased tire pressure test, it showed the effect on rutting to be directly proportional to the pressure.

Analysis of MMLS3 findings

The MMLS3 stress profile enabled rutting under the MMLS3 to be compared to that from under the MLS. The uncorrected MMLS3 ruts in the upper 90 mm AC surface layers were 1.6 to 2.3 times greater than the MLS ruts for similar axle loads. After correcting for temperature and stresses, the comparable ratios varied between 0.9 and 1.3. This provides a sound basis for using the MMLS3 in conjunction with the MLS.

The Researchers Recommend...

This study program provides a sound framework for the application of the MLS in conjunction with the MMLS3 as tools in an APT program. Accordingly, the researchers recommend that TxDOT incorporate the following guidelines in its future APT programs:

- Consider using the VESYS mechanistic analysis to strengthen the validation of its use in rut prediction. Also, use the newly developed quantitative analysis model, when different trafficking temperatures, unbalanced axle loads, and differences in structural support have to be taken into account.
- Use SASW together with FWD tests and MDD measurements for monitoring changes in material properties and changes in the pavement structure. Material characteristics should be determined with the Superpave test system.
- Consider using overloaded MLS axles or increased tire pressures to adjudicate performance of extraordinary pavement structures or new materials.
- Consider using wet MMLS3 testing to evaluate susceptibility of asphalt surface layers to moisture damage under traffic. ITS fatigue testing of the trafficked specimens can then be used to evaluate the remaining life. Heated MMLS3 tests can be used for supplementing the MLS tests when evaluating rutting of asphalt surface layers at high temperatures.

For More Details...

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The research is documented in the following reports:
Report 1814-1, *Report on a Comparison of the Effectiveness of Two Pavement Rehabilitation Strategies on US 281 Near Jacksboro.* May 2001
Report 1814-2, *Report on the First Jacksboro MMLS Tests.* February 2001
Report 1814-3, *Performance of Rehabilitated Lightweight AC Pavements Under Wet and Heated Model MLS Trafficking: A Comparative Study with the TxMLS.* May 2001
Report 1814-4, *Rutting Performance of Dustrol Rehabilitated Lightweight AC Pavements Under Web and Heated Model MLS Trafficking: A Comparative Study with the MLS.* June 2000.

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3138, email: ctrlib@uts.cc.utexas.edu

TxDOT Implementation Status
October 2001

No specific implementation project is envisioned for the use of this equipment. However, the new Texas Accelerated Pavement Testing Center (TxAPT) being created at the Pickle Research Campus of UT Austin is expected to use the equipment for specific studies of pavement structures, new asphalt mixes and other pavement materials. The primary implementation of the one-third scale Model Mobile Simulator (MMLS3) is in the screening of asphalt mixes with unacceptable rutting performance, prior to use in either full-scale in-service pavement structures or in accelerated pavement testing (APT). The Materials Section of the Construction Division is also using the MMLS3 for laboratory and field studies of the performance of asphalt mixes.

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Your Involvement Is Welcome!

Disclaimer

This research was performed in cooperation with the Texas Department of Transportation and the U. S. Department of Transportation, Federal Highway Administration. The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement. The engineer in charge was Frederick Hugo, P.E. (Texas No. 67246).

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