TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 2134-S
Project 0-2134: Evaluation of Model Mobile Load Simulator Using WesTrack Sections

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PROJECT SUMMARY REPORT

Performance Prediction with the MMLS3 at WesTrack

Excessive rutting in hot mix asphalt (HMA) pavements creates a safety problem because vehicle steering becomes impaired and the danger of hydroplaning increases. Several millions of dollars are allocated annually to preclude these problems. Transportation agencies and roadway users could realize significant savings if engineers can accurately predict and thus minimize this type of distress through improved mix design and material selection. Accelerated pavement testing (APT) devices can be used as tools to facilitate prediction, but the cost of full-scale devices can be high.

In this project a one-third scale APT device, the Model Mobile Load Simulator (MMLS3), was evaluated to establish whether it could simulate rutting performance of a full-scale pavement under full-scale truck trafficking, provided differences in loading and environmental conditions are considered. The comparative study, supplemented with laboratory tests, was successful. This provided a sound base for the demonstration of two methodologies for utilizing the MMLS3 as a tool for prediction of actual field performance.

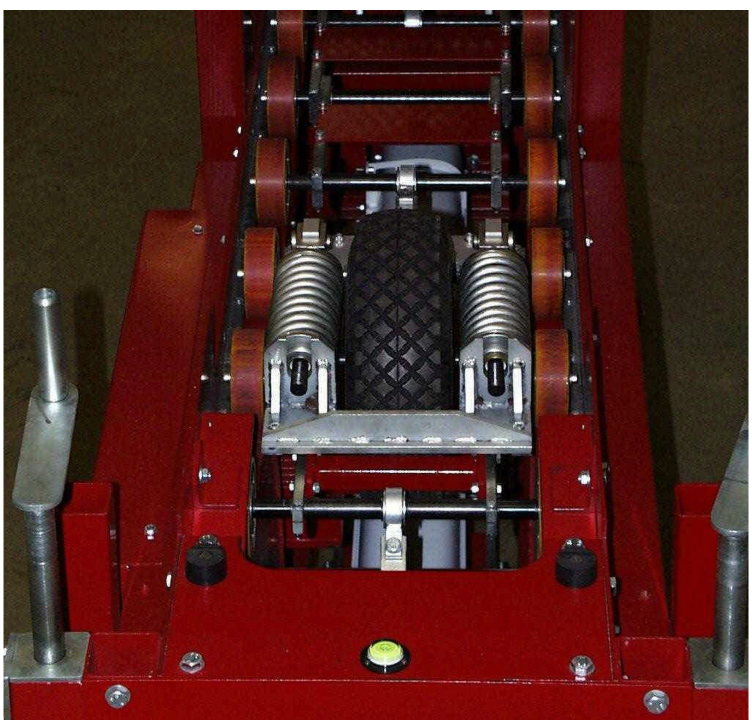

Figure 1. MMLS3

What We Did . . .

Accelerated Trafficking and Performance Monitoring

Five MMLS3 tests (including one replicate) were completed in an environmental chamber on four asphalt concrete pavement sections at WesTrack, a full-scale APT test track in Nevada (Figures 1 and 2). The scaled MMLS3 applied approximately 200,000 load applications of 2.1 kN (472.5 lbs) to each section. The surface pavement temperature was held constant at 60 °C (140 °F), while four pneumatic tires initially inflated to 690 kPa (100 psi) at 25 °C (77 °F) applied unidirectional loading at a speed of approximately 2.6 m/sec (8.5 ft/sec). This corresponds to a loading frequency of 4 Hz. For each section, researchers:

- measured transverse profiles before trafficking and in five performance monitoring sessions during the trafficking phase,
- monitored changes in modulus due to trafficking using Spectral Analysis of Surface Waves (SASW) measurements taken before trafficking and at two subsequent performance monitoring sessions,
- obtained cores before and after trafficking was completed to monitor densification and any change in indirect tensile strength, and
- cut specimens from cores for a limited laboratory testing

Figure 2. MMLS3 at WesTrack inside environmental chamber

program that included the Texas Department of Transportation (TxDOT) Static Creep test and wheel-tracking with the Hamburg Wheel Tracking Device (HWTD) and the Asphalt Pavement Analyzer (APA).

Rut Depth Analysis

Transverse profile data was analyzed using three different rut depth (RD) analysis methods. The Reference Method was based on a comparison of profiles before and after a specific amount of trafficking. The Single Profile Method compared a single profile measured after trafficking and corrected for cross slope to a horizontal datum defined as zero vertical elevation. For the Reference and Single Profile Methods, statistical analyses were completed to compare (1) sections for a given loading condition (MMLS3 or full-scale WesTrack trucks), (2) RD analysis methods for each section, and (3) performance under each loading condition by section. Subsequently, a Modified Reference Method was used to account for transverse profile measurement errors, misalignment of the MMLS3 during trafficking, and secondary permanent deformation. Differences in lateral wander necessitated the determination of comparable load applications and related RDs.

Performance Assessment and Prediction

Researchers ranked performance by section using laboratory results and field RD results determined by the Reference and Single Profile Methods of analysis for the two loading conditions after 100,000 load repetitions.

RD criteria were developed for use with MMLS3 testing to ensure adequate rutting performance. These criteria were based on specific conditions, namely 100,000 load repetitions, 10 mm (0.4 in) failure criteria under full-scale loading, the Reference Method of RD analysis, three replicate RD measurements, and a 95 percent reliability level. Researchers also presented a methodology for developing criteria for different reliability levels, numbers of replicate RD measurements, and failure criteria in the field.

Stress analyses were conducted as a basis for comparison of theoretical and actual rutting performance under the MMLS3 and full-scale trucks. The successful theoretical simulation of the rutting performance under the two loading conditions provided the basis for predicting performance from (1) MMLS3 testing and (2) a theoretical analysis using measured laboratory data and stress potentials based on the areas under the maximum vertical compressive stress distributions for both loading conditions. The analytical methodology involved a quantitative comparative analysis based on the hypothesis that the extent of rutting is dependent on the nature of the vertical contact stress under the tire, the material characteristics and pavement structural composition, and the prevailing environmental conditions prior to and during trafficking. When calculating the Theoretical Rut Ratios (TRR), factors were used to account for

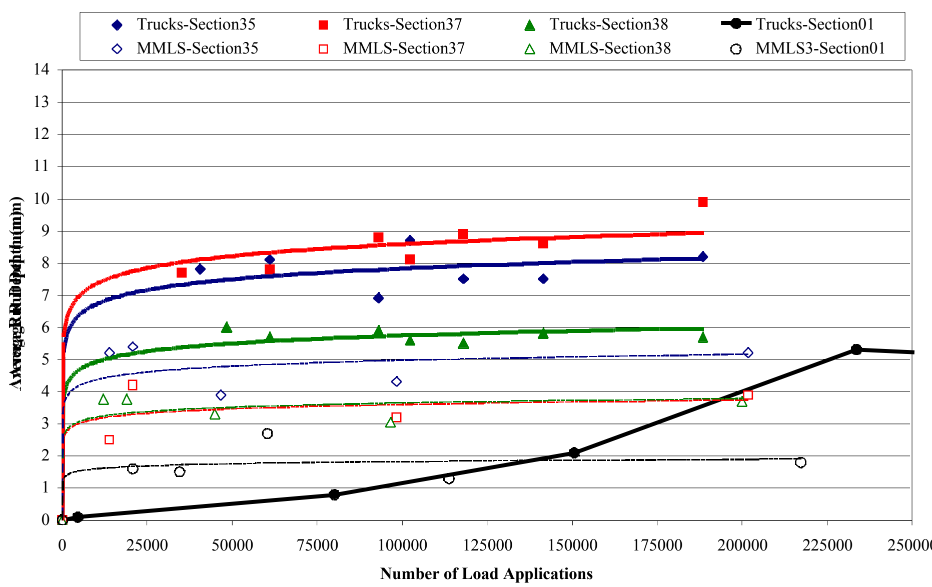

Figure 3. Reference method rut depths

Table 1. Performance ranking

(A= Best Rutting Performance)

Lab / Field Test (RD Analysis)	Section 01	35	37	38
RSST-CH to 5% γ_p	A	D	C	B
Aging by RSST-CH (G*@100reps)	A	D	C	B
Static Creep Stiffness	A	C	D	B
Static Creep γ_p	A	B	D	C
HWTD	A	D	C	B
APA	C	A	D	B
MMLS3 (Single Profile)	A	C	D	B
MMLS3 (Reference)	A	D	C	B
WesTrack Trucks (Single Profile)	A	C	D	B
WesTrack Trucks (Reference)	A	D	C	B

differences during MMLS3 and full-scale truck trafficking. Similarly, the comparable load applications and related RDs were used for calculating the Field Rut Ratios (FRR). The ratio of the TRR and FRR values then yielded the Rutting Prediction Ratio (PRRutting) value for each section.

What We Found . . .

Rut Depth Analysis and Qualitative Comparison

Figure 3 shows the RD results using the Reference Method.

- The MMLS3 successfully ranked the relative rutting performance of four independently trafficked WesTrack sections; however, RDs from Reference and Single Profile Methods of analysis were statistically different.
- The Reference Method proved to be the most reliable.

Performance Assessment and Quantitative Comparative Analysis

- All performance rankings based on field results using either RD analysis method were in close agreement (Table 1).
- The majority of the rankings based on laboratory tests were consistent with field results (Table 1).
- MMLS3 trafficking caused densification and a corresponding slight increase in SASW modulus. As expected, no changes in indirect tensile (IDT) strength were found.
- RD criteria were developed for specific criteria, with a maximum average RD (Reference Method) of 3.5 mm (0.14 in) under the MMLS3 for three transverse profiles after 100,000 load repetitions at the critical temperature for permanent deformation over a hot summer period.
- The comparison between theoretical and actual rutting performance (PRRutting) initially exhibited some apparent inconsistencies, with ratios ranging from 1.3 to 2.0. This led to a second, more detailed analysis that included additional important factors necessary for successful implementation of the associated performance prediction methodology. These factors included lateral wander effects, transverse profile measurement errors, misalignment of the MMLS3, and tire contact stresses at elevated temperatures. This more comprehensive analysis involved improving material property estimates, revising RDs using the Modified Reference Method, considering deformation throughout the pavement structure, and accounting for differences in lateral wander between the two loading conditions. Resulting PRRutting values of 1.0, 1.1, 1.2, and 1.0 indicated that the hypothesis required for this methodology appears to hold for the four independent pavement sections at WesTrack, provided steps are taken to factor in differences in loading and environmental conditions between MMLS3 and full-scale truck trafficking. As a corollary, this finding provides the basis for predicting full-scale rutting performance from the results of MMLS3 tests on condition that all factors are taken into account with the analysis. This would necessitate predicting future trafficking conditions and related estimates of material parameters.

The Researchers Recommend . . .

Results of this study lend credence to and confidence in the use of the MMLS3 as a pavement performance prediction tool. It also provides a method for screening mixtures with unacceptable rutting performance, prior to use in either full-scale APT studies or in-service pavement structures.

Researchers recommend the following procedure to predict rutting performance using the MMLS3:

1. Select the critical temperature for permanent deformation over the hottest week in the summer of a 30-yr period.
2. Traffick the section for 100,000 load repetitions.
3. Measure three transverse profiles and determine average RD using the Reference Method with careful measurement and review of transverse profiles during trafficking.
4. Estimate if rutting resistance is adequate by comparing the average RD with criteria provided or developed for different conditions.

OR ALTERNATIVELY

5. Determine the theoretical rutting ratio based on areas beneath maximum vertical compressive stress curves with depth for full-scale and scaled (MMLS3) loading and representative loading and environmental conditions and related material properties.
6. Estimate rutting performance under full-scale loading using the average MMLS3 RD according to the Modified Reference Method and assuming a PRRutting value of 1.0.

Researchers also encourage comparative analyses of rutting performance under both the MMLS3 and full-scale APT to further validate the required hypothesis for quantitative performance prediction. Such analyses must take special care to account for all factors affecting rutting performance.

For More Details . . .

The research is documented in Report 2134-1, *Performance Prediction with the MMLS3 at WesTrack.*

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To obtain copies of the report, contact Dolores Hott, Texas Transportation Institute, Information & Technology Exchange Center, (979) 845-4853, or e-mail d-hott@tamu.edu. See our catalog on-line at http://tti.tamu.edu.

TxDOT Implementation Status
March 2001

The primary implementation of the one-third scale Model Mobile Simulator (MMLS3) is in the screening of mixtures with unacceptable rutting performance prior to use in either full-scale in-service pavement structures or in other accelerated pavement testing (APT). No specific implementation project is envisioned for the use of this equipment. However, the Materials Section of the Construction Division is expected to use this equipment for specific studies of new mixes.

For more information, please contact German Claros, P.E., RTI Research Engineer, (512) 467-3881, or e-mail gclaros@dot.state.tx.us.

YOUR INVOLVEMENT IS WELCOME!

DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the U.S. Department of Transportation, Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the 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, 67246).