HIGHLIGHTER

PROJECT TITLE
FIELD PERFORMANCE MONITORING AND MODELING OF INSTRUMENTED PAVEMENT ON I-35 IN McCLAIN COUNTY

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FIELD PERFORMANCE MONITORING AND MODELING OF INSTRUMENTED PAVEMENT

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OVERVIEW Flexible pavements comprise about 93 percent of paved roads in the United States. Although flexible pavements are widely used for reasons such as cost, constructability and consistent performance, they are often subject to severe rutting and fatigue cracking. This study combined laboratory and field tests to provide a better understanding of the mechanisms that cause pavement failure under actual traffic loading and environmental conditions.

RESULTS A 1,000-ft. long experimental pavement section was constructed on I-35 in McClain County and instrumented in collaboration with the National Center for Asphalt Technology (NCAT) and the Oklahoma Department of Transportation (ODOT) for field data collection (Figure 1).

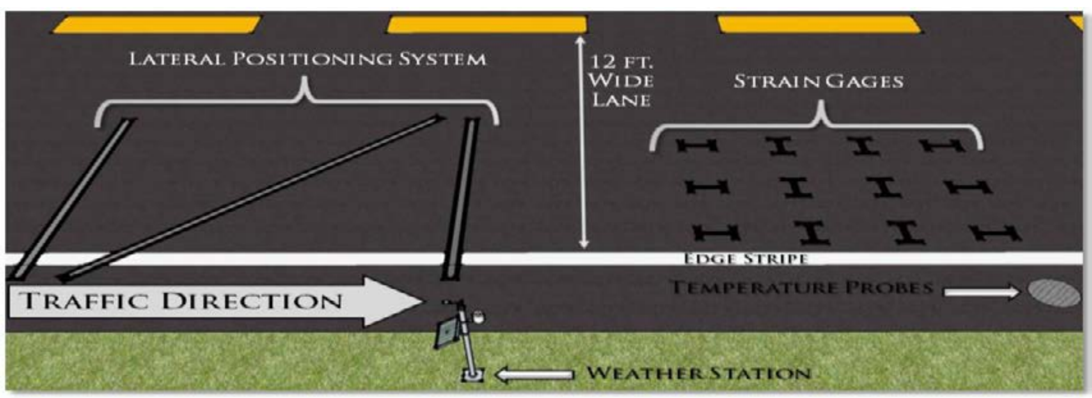

Figure 1 Instrumented I-35 Test Section

The test section, which consisted of pavement layers of subgrade soil, stabilized subgrade, aggregate base and hot mix asphalt (HMA), was designed to fail in a relatively short amount of time under heavy interstate traffic. The field data was collected over a six-year period and focused on pavement response data (longitudinal and transverse strains at the bottom of the asphalt layer), environmental data (moisture, temperature within the pavement), performance data (rut, cracks and roughness on the surface of the pavement) and actual traffic data (number of trucks, axles, and axle load).

Models were developed based upon the collected data. From the field data, rut and fatigue prediction models were developed. A separate statistical rut prediction model was also developed from the laboratory rut tests using the Asphalt Pavement Analyzer (APA). Additionally, from the laboratory four-point fatigue tests data, fatigue cracking susceptibility to temperature was analyzed. Predicting distresses using the Mechanistic Empirical Pavement Design Guide (MEPDG) software was also addressed.

Accurate prediction of rutting for an in-service pavement under actual vehicular traffic loading and environmental conditions is critical for effective pavement design. The output from rut models developed in this study demonstrated a high level of accuracy in predicting pavement field performance. Both vertical strain-based (Figure 2) and shear strain-based models predicted rutting with similar levels of accuracy (R^2 values of 0.86 and 0.80, respectively). The regression model developed from the laboratory (APA) rut data (with three independent variables air voids content, test temperature, and number of cycles) also exhibited a high level of accuracy (R^2 value of 0.91) for predicting pavement performance. This indicates improved rut prediction capability and a need for local calibration of deformation models in Oklahoma.

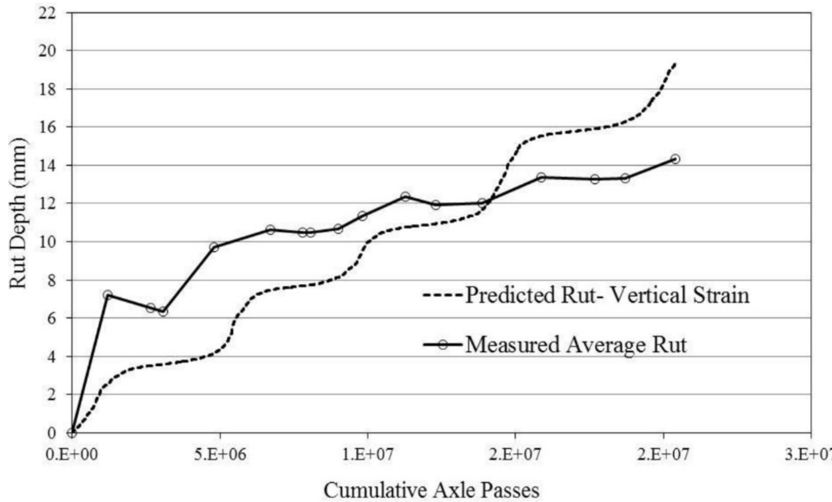

Figure 2 Vertical Strain Model Output and Field Rut Data

Accurate prediction of fatigue damage is also critical to design. A fatigue transfer function was developed to predict fatigue failure of the pavement. The fatigue model used in this study was based on the hourly temperature data, which was collected continuously. It was calibrated to fit the observed field performance. The field tests did not show significant change of stiffness over the testing period; therefore, regression coefficients were determined for an assumed damage ratio of 0.2. The laboratory four-point fatigue tests provided the initial stiffness values and number of cycles to fatigue failure of beams determined by initial tensile stress and strain. It was observed that an increase in temperature caused the initial flexural stiffness of beams to decrease and the number of cycles to failure to increase.

Figure 3 Forensic Investigation

Laboratory tests (e.g. Hamburg rut, four point beam fatigue, volumetric properties) were also performed on extracted samples from the test section. The contribution of different pavement layers to total rutting was assessed by a forensic investigation involving cutting full-depth trenches at three selected locations of the test section (shown left).

To gain the full benefit of pavement design using the MEPDG can be a challenging task. The MEPDG has three different input categories: (1) traffic, (2) climate and (3) materials. It also has three different levels of input data: Level 1, Level 2 and Level 3. Level 1 inputs, which require site-specific data based on field and laboratory tests, provide the highest level of accuracy and, therefore, would have the lowest level of uncertainty or error. Level 2 inputs (e.g. user-selected from agency database or estimation) provide an intermediate level of accuracy. Level 3 inputs are default values, which provide the lowest level of accuracy. Therefore, this study developed site-specific (Level 1) input parameters for traffic, climate and materials. Calibration of the rut prediction models was done by comparing the observed pavement performance with the MEPDG-predicted pavement performance (based upon the developed Level 1 input parameters for traffic and materials) over time.

It is not necessary nor efficient to collect and process continuous dynamic response data. This study demonstrated that strain-temperature and stiffness-temperature relationships can be developed to accurately predict the pavement response using data collected over a limited duration of time because relationships remain relatively stable after a certain time period. This study also provided the calibration of MEPDG rutting models based on site-specific data (versus default data) to enhance the accuracy of prediction of pavement field performance.

BENEFITS The results from this study will be useful in predicting rutting of state highway pavements under similar traffic and environmental conditions. Moreover, the field rut prediction models that were developed will be a helpful tool for state agencies that are implementing the Mechanistic-Empirical Pavement Design Guide (MEPDG).