ABSTRACT

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. Rutting is the accumulation of longitudinal depressions under the wheelpaths caused by the repeated traffic loads. Rut is a major concern for the integrity of pavement structure and traffic safety. Accordingly, it is important to study progression of rut under actual vehicular traffic loading and environmental conditions and to predict such rutting using laboratory and field data.

To gain an insight of flexible pavement rutting under actual vehicular traffic and environmental conditions, a 1,000-ft. long test section was constructed on I-35 (Southbound) in McClain County, Oklahoma and instrumented for field data collection. In addition, a weigh-in-motion (WIM) station was installed approximately three quarter mile down the test section, and was used for traffic data collection. Field rut measurements were conducted periodically to monitor performance of the test section using a Straight Edge/ Rut Gauge combination and a Face Dipstick®. WinJULEA, commonly used multilayered linear elastic analysis software, was used to model the test section and determine rut due to axle (single and tandem) loading. Data obtained from the test section was used to develop field rut prediction models. In the development of the field rut prediction models, two different approaches were examined. First, a vertical strain-based rut prediction model was developed using the measured rut on test section and relating it to vertical strain on the top of the aggregate base layer due to passing of each vehicle. Second, a shear strain-based rut prediction model was developed using the measured rut on test section and relating it to shear strain in the Hot Mix Asphalt (HMA) layer of the test section due to passing of each vehicle. A total of about 2.2 million vehicles (approximately 9 million accumulated axles) and two years of environmental data were used to develop the field rut prediction models. By relating the measured hourly rutting to the vertical/shear strains and the total number of axles traversing the test section during that particular hour, rut prediction models were developed by performing a non-linear regression analysis using a least–square method. The correlation coefficient (R² value) for these models was around 0.84, based on the comparison of measured and predicted ruts.

A separate statistical rut prediction model was also developed from the laboratory rut tests using the Asphalt Pavement Analyzer (APA) rut machine. A total of 100 specimens were compacted at different air voids ranging between 1 and 11% using a Superpave Gyratory Compactor (SGC). Out of these 100 specimens, a total of 31, 26 and 44 specimens were tested in the APA rut machine at 40°C (104°F), 50°C (122°F), and 64°C (147°F), respectively. In the laboratory rut prediction model, rut depths were correlated with three independent variables namely, air voids of the compacted sample, test temperature, and number of loading cycles. The correlation coefficient (R² value) between the observed and the predicted rut values was obtained as 0.91. A sensitivity analysis was performed on the developed model. Results from the sensitivity analysis demonstrated that temperature is the most sensitive variable, followed by air voids and number of loading cycles. The results from this study are expected to be useful in predicting rutting of state highway pavements under similar traffic and environmental conditions. Specifically, the field rut prediction models developed in this study can be used to calibrate the “transfer functions” in the Mechanistic Empirical Pavement Design Guide (AASHTO, 2004) for successful implementation by the state agencies.