CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 0-5372-S
Project 0-5372: Testing of HB2060 Pads
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PROJECT SUMMARY REPORT

Equivalent Damage and Fatigue Testing of the HB 2060 Pads

Texas currently has approximately 17,000 miles of load-zoned roads, the majority of which are posted at 58,420 lbs. These roads consist predominantly of thin pavement structures constructed in the 1940s and 1950s, originally designed to carry the lighter loads of those times. In 1989, the 71st Texas Legislature passed House Bill 2060 (HB 2060), which established a $75-per-county permit that allows truckers to carry legal loads (80,000 lbs plus a 5 percent GVW tolerance = 84,000 lbs) on load-zoned roadways and bridges. Previous research has indicated that the HB 2060 permit fee does not provide sufficient revenue to compensate for the damage caused by these heavy loads. This conclusion was based on an evaluation of the damage models in the 1993 American Association of State Highway and Transportation Officials (AASHTO) guide Design of Pavement Structures, Chapter 4, "Low-volume Road Design," and a field study. Although this information was compelling, the HB 2060 permits are still available to truckers who choose to operate on the state's load-zoned road network.

Accelerated Pavement Testing (APT) technology has the potential to provide valuable information that, in a relatively short time, could demonstrate the damage caused by heavily loaded trucks to the load-zoned road network. Accelerated Pavement Testing of pavements is widely accepted as an important aid in decision-making for material characterization and pavement design, analysis, and performance. APT technology is perfectly suited to address the problem described in this research and to obtain visible short-term results. For this reason, the Center for Transportation Research (CTR) at The University of Texas at Austin proposed to conduct controlled, accelerated pavement tests to evaluate the increased damage to thin pavement structures caused by increasing axle loads. The research project was planned under the assumption that the Texas Mobile Load Simulator (TxMLS) would be available as the APT device.

The first objective of the research was to quantify the response and performance of a relatively light pavement structure with increased traffic load applications under the TxMLS. The second objective of the series of four tests was to compare the performance of the same pavement structure under different axle loads. In turn, this activity could serve as an experiment to validate currently used approaches to estimate equivalent damage, specifically the value of the exponent of the so-called power-law, which postulates that the damaging effect of an axle increases exponentially with its load (an exponent of four is generally accepted). The third objective was to develop a methodology to estimate the reduction of expected pavement performance as a result of increased axle load. The development of this methodology was to be based on the data collected during the course of Project 0-5372 and was to be used to facilitate the development of guidelines to estimate load equivalency factors for similar pavement structures to those tested under the TxMLS, expanding the test results to a bigger inference space.

What We Did ...

The contract responsible for renovating the TxMLS and providing the necessary traffic to carry out Project 0-5372

was discontinued in August 2005. At that time, approximately 40,000 axle load repetitions had been applied to one of the test pads, an amount which did not provide the data necessary for addressing the objectives described above. For this reason, this project could address only part of the third objective, i.e., the development of a methodology for the estimation of pavement damage under different axle loads and configurations. This methodology was based on the recently developed guide for the Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures, commonly referred to as the M-E Design Guide. The guide was developed under National Cooperative Highway Research Program (NCHRP) Project 1-37A.

The M-E Design Guide was used in this research for the evaluation of pavement performance and for the determination of Equivalent Damage Factors (EDFs). The following four major variables were considered in this project:

1. Pavement structural capacity expressed in terms of the structural number (SN).
2. Environmental conditions: five locations representative of the most typical Texas conditions.
3. Axle loads for single and tandem axles.
4. Performance in terms of surface rutting and fatigue cracking.

The failure criterion in terms of surface rutting was 0.5 in., and in terms of fatigue cracking, it was 10 percent. When compared to the empirical design based on AASHTO's 1993 guide, the mechanistic-based analysis estimated longer pavement lives for thinner pavement structures. On the other hand, for thicker pavement structures, the mechanistic-based analysis estimated longer pavement lives in terms of fatigue and shorter pavement lives in terms of rutting. However, it should be emphasized that the failure criterion used in the AASHTO 1993 guide is based on serviceability in terms of the present serviceability index (PSI).

In addition, Project 0-5372 evaluated the laboratory fatigue performance of the asphalt mixture used for the construction of the HB 2060 test pads. The asphalt mixture was tested under several conditions and compared with other typical TxDOT mixes with and without modifiers.

What We Found ...

Equivalent Damage Factors

Based on the performance analyses, it was observed that pavements in Amarillo, Texas are expected to experience the slowest deterioration rates compared to the four other Texas regions evaluated during this project. The observations made in Amarillo were attributed to the colder weather in that area. On the other hand, the fastest pavement deterioration was predicted in Austin and El Paso, compared to the remaining three locations, which could be attributed to the warmer climates of those areas.

The effect of using different axle loads for single axle and tandem axles was also investigated as part of this research. It was observed that as the axle load was increased, the pavement deteriorated at a significantly faster rate, requiring a lower number of axle repetitions to reach failure conditions. It was also observed that as the axle load increased, the fatigue-based Equivalent Damage Factors (EDF) increased at a much faster rate compared to the rutting-based EDF. This finding supports using higher exponents when calculating fatigue-related load equivalent factors by means of the power-law.

Another important finding indicates that as the structural number increases to some critical value, fatigue life decreases. As the structural number increases above this critical value, the fatigue life increases. This critical value of the structural number was between 3 and 4. A similar result was observed in the case of pavement performance in terms of surface rutting.

Fatigue Testing

Four-point bending beam fatigue tests (Figure 1) were conducted as a part of the laboratory testing program to acquire knowledge about the fatigue response of the mixture used for the construction of the HB 2060 test pads. This mix was compared with other typical TxDOT mixes to identify

Figure 1: Four-point Bending Beam Test Apparatus

the advantages of using modified binders with respect to fatigue life.

It was observed that the flexural stiffness-cycles curve typically shows a drop in stiffness after the point corresponding to 50 percent of initial stiffness. This drop is important to capture, as it leads to a significant loss of strength with only a few load repetitions. The termination criterion of 50 percent of initial stiffness does not capture this drop and, therefore, alternative failure criteria should be considered.

The traditional fatigue model was also verified for the HB 2060 mixture. The strain levels in the field are typically lower than the strain levels used for the tests; however, it is not recommended that beams be tested at low strain levels, as the tests at low strain levels imply long testing times. Based on the linear nature (log-log scale) of the fatigue curve obtained from the experiments and conclusions from other research studies, testing at two higher strain levels is sufficient to capture the behavior of the mix at the lower levels.

Fatigue tests were carried out for two different binder contents for the Superpave D mixture. Increasing the binder content (for binder contents greater than the optimum binder content for the mix as obtained by the Superpave method) increases the fatigue life.

The hypothesis of using cumulative dissipated energy as a criterion to compare the results of tests carried out under different conditions was investigated. The data analyzed did not provide enough evidence to support this hypothesis when the termination criterion was 50 percent of the initial stiffness. When the termination criterion was 20 percent of the initial stiffness, the hypothesis was supported.

The Researchers Recommend…

Accelerated Pavement Testing

The TxMLS was decommissioned in June 2006, but the HB 2060 sections constructed as part of the research were not tested and are still available. It is recommended that as the Department regains APT capabilities, the testing of these sections should have the highest priority because they have the potential to produce significant results with a minimum investment. Accelerated pavement testing has been shown to be a cost-effective and efficient technology worldwide, and there is no reason why this should not be the case in Texas.

Equivalent Damage Factors

The methodology developed in Project 0-5372 for the estimation of mechanistic-empirical equivalent damage factors (EDFs) has a number of advantages over existing empirical-based approaches. However, the development was based on a previous version of the guide for the Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures, which was known to suffer from lack of local calibration as well as programming errors. Hence, it is recommended that the approach be reviewed as soon as the final version of the M-E Design Guide is available. Version 1.00 of the M-E Design Guide is expected to be released in summer 2006.

Fatigue Testing

Four-point bending beam testing remains the most representative and flexible means for assessing the fatigue resistance of asphalt mixtures under different conditions. However, as a result of budget and time constraints, these mixtures were not fully evaluated and testing was often limited to satisfy some established specifications. It is recommended that the Department embark on a study to characterize the fatigue characteristics of the most popular mixtures used in the state. These mixtures should be evaluated under a wide range of conditions, including variables such as density, temperature, frequency, strain level, and terminal condition, and rather than being evaluated simply to meet a given specification. It is expected that findings from such a study may offer insight and solutions to the current problem of premature fatigue cracking observed on the Texas highway network.

For More Details...

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The research is documented in the following report:

5372-1 *Testing the HB2060 Pads: Equivalent Damage and Fatigue Testing*

To obtain copies of a report: CTR Library, Center for Transportation Research, (512) 232-3126, email: ctrlib@uts.cc.utexas.edu

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