Long Term Validation of an Accelerated Polishing Test Procedure for HMA Pavements

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Project Background

Highway accidents are a leading cause of death and injury in the United States. Between 1990 and 2000, an average of 6.4 million highway crashes occurred annually nationwide. The frictional properties of pavement surfaces play an important role in highway safety, as pavement surfaces must maintain an adequate level of friction at the tire pavement interface in order to provide a safe surface for traveling vehicles. The Ohio Department of Transportation (ODOT) has set strategic goals to improve driving safety on Ohio roadways by maintaining smooth pavement surfaces with high skid resistance. ODOT has taken the initiative to measure and monitor the skid number (SN; a number representing the friction properties measured by a locked wheel skid trailer) for pavement sections in areas where a high rate of wet weather related accidents occur. Once the measured SN falls below a certain threshold value, ODOT resurfaces the pavement to maintain high skid resistance and ensure driving safety. The practice of monitoring and remedying the pavement sections with low skid resistance is important; however, it is a passive and reactive approach toward the problem. A more proactive approach would be to test hot mix asphalt (HMA) in the laboratory during the mix design stage to ensure that aggregates used in the HMA will provide adequate friction as expected over the life of the pavement. Ensuring the use of appropriate aggregates to provide friction over the pavement life expectancy is a desirable goal.

A laboratory scale, research grade, accelerated HMA polishing machine was developed by the author in a previous study. The capability of the research grade polishing machine was evaluated through a series of validation tests, including repeatability, comparisons with British Wheel Test results of aggregate samples, and image analysis of the exposure area of aggregates during the polishing test. A tentative test procedure and the associated acceptance criteria were also
recommended in the previous study. Nevertheless, very limited resources were spent at that time to collect field performance data for comparison with laboratory obtained polishing data using the developed accelerated polishing machine.

With the validity of the research grade polishing machine established and the initial limited performance data collected with fairly positive results in comparison to the lab test data, ODOT proceeded to conduct a long-term field study in order to collect field performance data over a longer time period. To this end, this research was initiated to focus on long-term validation of an accelerated polishing test procedure for HMA pavements. However, since polishing rates are non-linear and mix gradation and aggregate sources are varied, it was recognized that statistical methods need to be used to develop any predictive models for friction degradation with traffic for any given material properties measured by the accelerated polishing machine.

**Study Objectives**

The main objective of this research is to further validate the applicability of the previously developed laboratory test protocol and acceptance criteria through a correlation and comparison study with long-term field performance data. In addition, a production grade polishing machine based on the design principles of the research grade polishing machine will be developed and delivered to ODOT lab for routine use. The specific objectives can be enumerated as follows:

- Continue to improve and refine the laboratory test protocols to ensure ease of implementation by potential users such as contractors, aggregate producers, and ODOT material engineers;
- Validate the acceptance criteria by relating lab measured time-dependent friction loss behavior to the time history of field performance data using selected pavement test sections throughout Ohio;
- Develop ODOT supplemental specifications incorporating the developed equipment and test procedures for friction/polishing criteria during the mix design of HMA for surface courses.

**Description of Work**

A review of relevant literature was conducted to ensure that the current research trend in the area of aggregate friction and polishing was critically evaluated. It is noted that this research has yielded many important findings and deliverables that are not available from other current research efforts. Most prominent among these is the development of a commercial grade asphalt polisher that provides an effective method to test gyratory compacted samples for quantifying the time-dependent polishing and friction behavior of HMA samples. In addition, friction degradation models for in-service asphalt pavement that were developed and validated in this research represent an integrated and comprehensive approach to forecasting the friction performance of HMA using lab test data, material characteristics, and field traffic information. Finally, a supplemental note was delivered to ODOT for consideration as a procedure for evaluating the suitability of a particular JMF and aggregate source for a pavement project with consideration of project specific traffic data. The work performed under this research is
summarized below.

- Field work was carried out to measure friction and texture data on six selected pavement sections for the years of 2010, 2011, and 2012. Additionally, coordination with ODOT personnel was made to obtain SN data using ODOT’s locked wheel skid trailer. In 2012, additional friction and texture measurements were collected on the shoulders of the selected pavement sections to serve as a surrogate for the initial friction and texture data.

- Analysis of field data was performed to see the trend of time-dependent variation in friction and texture for the six pavement sections. A general trend of degradation with increasing in-service years can be observed, even though there was significant scattering of data points.

- A new commercial grade accelerated polishing machine, “The Polisher,” was fabricated based on the design principles of the previously developed research-grade polishing machine. The commercial grade polisher was designed to handle only standard gyratory compacted samples with a 6-inch diameter. The operation parameters – such as vertical force, the rotational speed of polishing disc, and the rate of water flow onto the contact between the rubber disc and the sample – were fixed for simplicity and ease for maintenance. The comparison of test results between the research-grade machine and the commercial grade polisher confirms that the new polisher can reproduce the same result as the research-grade machine. An operations manual for “The Polisher” is provided in an appendix of the report. Photos of the machine and an inside view of the test chamber are presented herein.

- Models for predicting the field performance of asphalt pavement friction under traffic were developed. The predictors for SN(64)R (i.e., skid number measured at 64 km/hr speed using a ribbed tire) included the friction degradation curve obtained from the polishing machine, parameters for the characterizing the aggregate gradation curve, and traffic data. The predictors for the International Friction Index, represented by F(60), were the same as those for SN(64)R, but with one additional predictor of the mean texture depth (MTD) degradation curve. The developed prediction models were tested satisfactorily for accuracy for the six pavement sections studied in this research effort.

- Supplemental notes were developed for possible implementation by ODOT to evaluate the suitability of a JMF for a particular pavement construction project.
Research Findings & Conclusions

The conclusions from this study can be summarized as follows.

- The friction and texture data measured in the field for the six pavement sections showed significant scattering, even though efforts were made to conduct measurements at the same mile markers and same physical spots on the wheel path. The scattering can be attributed to high spatial variability as well as to uncertainties of environmental effects.

- The International Friction Index (IFI), by virtue of integrating friction and texture measurements and harmonizing differences in the measurement devices, appeared to be a useful index to represent friction and texture characteristics. As such, the use of IFI should be embraced by ODOT in future work.

- The functionalities of the new commercial grade accelerated polishing machine for gyratory compacted 6-inch-diameter samples have been validated. The design specifications of the machine were provided in the report. The use of “The Polisher” or other equivalent machines that satisfy the design requirements can be accepted in the lab for routine testing purposes.

- The prediction models for degradation of friction, either SN(64)R or F(60), have been developed and compared with field measured data. It appeared that the predictive equations could be used to forecast in service performance of asphalt pavement surface friction.

Recommendations for Implementation of Research Findings

The following recommendations are made for possible implementation:

- A commercial-grade polishing machine known as “The Polisher,” an apparatus developed in a previous research effort, could be adopted for use as an efficient laboratory test device to determine friction and polishing behavior of gyratory compacted HMA samples. Alternatively, the design specifications outlined in the report can be used to allow other interested commercial entities to fabricate an equivalent accelerated polishing machine.

- The supplemental notes presented in an appendix of the report could be adopted by ODOT to evaluate the suitability of a JMF with a particular aggregate source for a specific pavement construction project.