Friction Surface Treatment Selection: Aggregate Properties, Surface Characteristics, Alternative Treatments, and Safety Effects

Introduction

For this project, in-depth reviews were conducted to identify the property aspects of aggregates used for high friction surface treatment (HFST), including aggregate abrasion value (AAV), Los Angeles abrasion (LAA), Micro-Deval abrasion, and polished stone value (PSV). Extensive laboratory testing was conducted to examine the selected property aspects for the calcined bauxite and steel slag that may be used in Indiana. Both laboratory accelerated polishing and true traffic polishing were carried out to evaluate the effects of aggregate properties and the long-term friction performance of the HFST candidates.

Field friction test data was utilized to evaluate the long-term friction performances of chip seal, microsurfacing, ultrathin bonded wearing course (UBWC), and diamond grinding. Statewide vehicle crash data over a 5-year period was examined to determine the crash statistics associated with pavement friction. Statistic models were developed to predict the crash rate in terms of pavement friction for interstate, US, and state highways, respectively.

Findings

Aggregate Mechanical, Physical, Chemical, and Geometric Properties

- The PSV of BS EN 1097-8 test differs from the polish value, i.e., PV-10 of ASTM D3319-11, in many aspects, such as load, polishing time, abrasion condition, and reading scale. The Micro-Deval abrasion test was reported to be a better indicator for the durability of aggregate. The exposed aggregate particles of HFST protrude above the binder and undergo greater shear force and impact from vehicle tires, which may be measured in terms of LAA.

- The LAA loss increased as aggregate size decreased, regardless of aggregate type. Steel slag experienced greater LAA losses than calcined bauxite. However, the difference between the LAA losses of calcined bauxite and steel slag became much smaller as aggregate size decreased. Steel slag experienced a greater Micro-Deval abrasion loss than calcined bauxite. The 1/3-mm aggregates yielded greater polish value than the 6.3/9.5-mm aggregates for both calcined bauxite and steel slag. The polish values for 1/3-mm aggregates also demonstrated greater variations than those for 6.3/9.5-mm aggregates.

- Specification requirements for the mechanical properties of aggregates in terms of LAA, Micro-Deval abrasion, and PV-10 can be easily implemented by the state departments of transportation (DOTs).

- Synthetic aggregates such as calcined bauxite tend to contain an excessive amount of rounded particles. It is necessary to minimize the content of rounded particles with reference to a minimum fine aggregate angularity (FAA).

Evaluation of Friction under Laboratory Accelerated and True Traffic Polishing

- Under laboratory accelerated polishing, the HFST candidates with No. 8 steel slag (1–5 mm) and No. 4 calcined bauxite (1–5 mm) yielded similar mean profile depth (MPD) values before polishing. After polish conditioning, the three candidates—No. 8 steel slag, No. 4 calcined bauxite, and No. 6 calcined bauxite—demonstrated a reduction of 20%, 18%, and 22%, respectively, in MPD and a reduction of 8%, 4%, and 4%, respectively, in terms of DFT friction at 20 km/h. Smaller aggregates tended to experience greater reduction in MPD. Nevertheless, the candidates with
larger surface MPD did not produce greater surface friction.

• Under true traffic polishing, the MPD values were 2.27 mm, 1.98 mm, and 1.98 mm before traffic polishing; 1.46 mm, 1.60 mm, and 1.58 mm after 3 months of service; and 1.49 mm, 1.46 mm, and 1.60 mm after 9 months of service for one-course No. 8 steel slag, one-course No. 6 calcined bauxite, and two-course No. 6 calcined bauxite, respectively. The average DFT friction coefficients at 20 km/h were 0.682, 0.932, and 0.905 after 3 months of service and 0.540, 0.812, and 0.798 after 9 months of service for these three candidates, respectively.

Long-Term Friction Performance of Preservation Treatments

• Applying a fog seal onto a new chip seal tended to reduce the surface friction by 25%. Chip seals using crushed stone demonstrated friction 25% greater than that using crushed gravel. No clear trend existed to indicate the differences in surface friction between No. 11, No. 12, and No. 16 aggregates. A successful chip seal is capable of providing satisfactory friction performance for a period of 5 years or more.

• Microsurfacing surface friction increased in the first 12 months and afterwards decreased very slowly, remaining very stable over time. Overall, microsurfacing is capable of providing better surface friction than chip seals for a wide range of traffic volumes and providing durable friction over a period longer than 6 years.

• UBWC surface friction tended to increase in the first 6 to 10 months, then decreased between 6 and 30 months in service. Afterwards, the friction fluctuated around a certain value greater than 30. UBWC with limestone aggregate demonstrated greater variation in friction properties. UBWC is capable of maintaining durable, sound surface friction for a period of at least 8 years under high traffic conditions.

• On hot-mix asphalt (HMA) pavement, diamond grinding surface friction fluctuated over time, and no trend existed to indicate a significant reduction in surface friction. On concrete pavement, such a surface friction decreased over time. Diamond grinding on new concrete pavement produced greater friction than on old concrete pavement. It can provide durable, sound surface friction for both concrete and asphalt pavements.

Quantifying Effectiveness of Friction Surfacing

The proposed crash-friction prediction models were developed from well-documented crash and friction data, and, therefore, are capable of providing reliable results.

Implementation

The laboratory aggregate test and analysis results have been utilized to determine the aggregate specification requirements for the HFST program recently implemented by the Indiana Department of Transportation (INDOT). The results of both laboratory accelerated and field true traffic polishing have also been used to establish the surface MPD and friction requirements for HFST. The regression models for predicting the long-term friction performance of pavement preservation treatment can be used to estimate the surface friction of chip seal, microsurfacing, UBWC, and diamond grinding over the periods of anticipated service lives for the particular treatment. The models for quantitatively predicting the association between pavement surface friction and crash probability can be utilized to determine the dynamic crash modification factors (CMFs) for friction surfacing, including HFST and conventional friction treatments, with respect to interstate, US, and state highways.

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