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Development of Surface Friction Guidelines for LADOTD

INTRODUCTION

The current Louisiana Department of Transportation and Development (LADOTD) surface friction guidelines deal with the polished stone values (PSV) of coarse aggregates (which is a relative British Pendulum skid-resistance number measured on polished stones). The basic assumption is that coarse aggregates with high PSV values will automatically provide sufficient surface friction for a wearing course mixture. However, the field measurement on friction resistance sometimes does not necessarily support such an assumption. In fact, there are many variables/parameters that may affect pavement surface friction resistance, and the PSV is just one of them. The use of only PSV of coarse aggregates has somewhat clouded the fundamental issues related to skid resistance of a pavement surface.

In addition, since very limited highly friction-resistant aggregates are locally produced in Louisiana, such friction guidelines will often tend to screen out locally available materials by requiring the imported highly friction-resistant aggregates in a wearing course, which may not be cost-effective.

OBJECTIVE

The main objective of this study was to develop a Louisiana pavement surface friction guideline that considers polished stone values and mixture types in terms of both micro- and macro-surface textures.

SCOPE

To achieve the objective, a comprehensive laboratory testing program was designed to evaluate the effects of different aggregates and asphalt mix types on pavement surface friction characteristics. Laboratory tests for aggregates included the British Pendulum, Micro-Deval and Aggregate Imaging System (AIMS) tests. The frictional characteristics of mixtures were determined using a laboratory accelerated slab-polishing device developed at the National Center for Asphalt Technology (NCAT), Dynamic Friction Tester (DFT), and Circular Track Meter (CTM) tests.

METHODOLOGY

Two coarse aggregate sources and four typical Louisiana hot-mix asphalt (HMA) wearing course mix types were selected for the purpose of the research. The selected aggregates included a crushed sandstone source (with high PSV) and a silicious limestone source (with low PSV). The selected wearing course mix types were a 19-mm Superpave Level-II mix, a 12.5-mm Superpave Level-II mix, a stone matrix asphalt (SMA) mix, and an open graded friction coarse (OGFC) mix. Each wearing course mix type was further designed using three different coarse aggregate blends (i.e., 100 percent sandstone, 100 percent limestone, and a combination blend of 70 percent limestone and 30 percent sandstone) and four mix types resulting in 12 HMA mixtures as outlined in Table 1.

To evaluate the texture and degradation resistance for the selected aggregates, three aggregate tests (the British Pendulum, AIMS, and Micro-Deval) were performed. Since the current HMA specifications do not provide any standard friction test procedure during mix design, an NCAT polishing/friction testing procedure for rapidly evaluating the frictional performance of HMA mixtures was selected for the research. This procedure requires the preparation of testing slabs based on linear kneading compaction method using a modified Hamburg Specimen Compactor. The slab dimensions of 20-in. by 20-in. allow testing of the surface frictional and texture properties using the DFT (ASTM E 1911) and CTM (ASTM E 2157) testing procedures.

Three replicate slabs were prepared for each of the 12 mixtures considered. Each slab was polished under the laboratory accelerated slab-polishing device for the cycle periods of 2, 5, 10,

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Table 1
Selected wearing course mixtures

No.	Mix Type	Mixture Designation
1	19-mm Superpave with 100% sandstone	SP19-SS
2	19-mm Superpave with 100% limestone	SP19-LS
3	19-mm Superpave with 70% limestone +30% sandstone	SP19-LS+SS
4	12.5-mm Superpave with 100% sandstone	SP12.5-SS
5	12.5-mm Superpave with 100% limestone	SP12.5-LS
6	12.5-mm Superpave with 70% limestone +30% sandstone	SP12.5-LS+SS
7	SMA with 100% sandstone	SMA-SS
8	SMA with 100% limestone	SMA-LS
9	SMA with 70% limestone +30% sandstone	SMA-LS+SS
10	OGFC with 100% sandstone	OGFC-SS
11	OGFC with 100% limestone	OGFC-LS
12	OGFC with 70% limestone +30% sandstone	OGFC-LS+SS

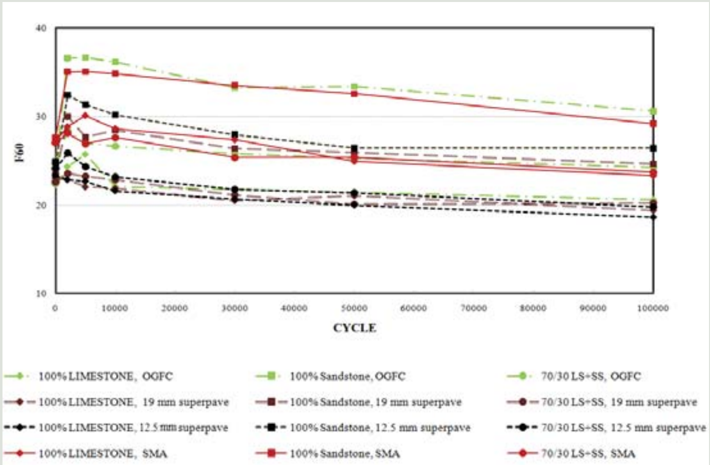

Figure 1
F(60) for different mix and aggregate type by polishing cycles

30, 50, and 100 thousand cycles, respectively. At the end of each cycle period, the polishing device was stopped and the slab was dried out for the evaluation of its surface macro- and micro-texture properties using the CTM and DFT devices, respectively. Figure 1 presents typical friction-resistance test results for the 12 HMA mixtures considered in terms of F(60) values under different polishing cycles. The F(60), so-called the International Friction Index (IFI) friction numbers at 60 km/hr, is a function of both macro- and micro-textures of a slab surface, which were measured using the CTM and DFT devices in this study.

By using DF20 (the DFT measured friction number at 20 km/hr) as a surrogate for micro-texture and the CTM measured mean profile depth (MPD) for macro-texture, a relationship between surface friction resistance F(60) and the micro-texture (DF20) can be constructed based on different macro-texture (MPD) levels, as shown in Figure 2.

In general, Figure 2 indicates that, to achieve the same level of design friction for a project, different pairs of micro-texture (DF20) and macro-texture (MPD) may be used. This implies potentially selecting low friction resistant aggregates in a mix design.

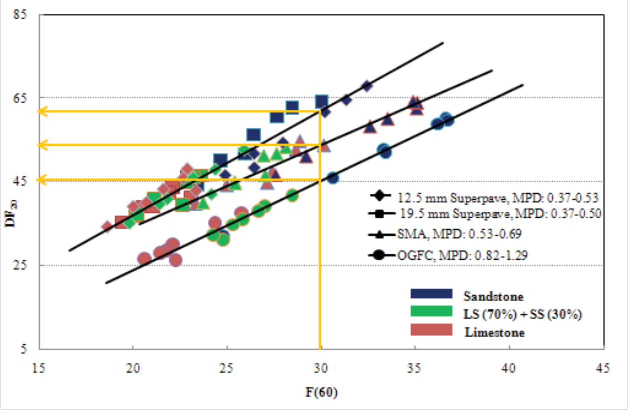

Figure 2
DF_{20} vs. F(60)

CONCLUSIONS

The laboratory results indicated that the DFT measurements were fairly sensitive to the coarse aggregate types (related to micro-texture), but not sensitive to mix types or aggregate gradations (related to macro-texture). The CTM measured MPD results confirmed a strong relationship between the macro-texture and mixture type. Further analysis of F(60) results showed that the selected OGFC mix type had the highest friction resistance due to its largest surface macro-texture (or MPD values), followed by the SMA mix type, and then by the two Superpave mix types considered. The F(60) results also indicated that the selected sandstone aggregate with high polishing resistance performed significantly better in mixture friction resistance than the selected limestone aggregate. Mixtures using an aggregate blend of 30 percent of the sandstone and 70 percent of the limestone tended to have a better surface friction resistance than those with 100 percent of the limestone. This observation demonstrates that blending of low and high friction aggregates together can possibly produce an asphalt mixture with an adequate field friction resistance. Finally, the analysis led to the development of a set of prediction models of mixture frictional properties and a laboratory mix design procedure that addresses the surface friction resistance of an asphalt mixture in terms of both micro- and macro-surface textures. The developed frictional mix design procedure allows estimating a friction-demand based, design friction number for an asphalt mixture during the mix design stage.

RECOMMENDATIONS

It is recommended that LADOTD consider implementing the frictional design procedure developed in this study. LADOTD should also consider implementing the results of the NCHRP 1-43, Guide for Pavement Friction, for the management of pavement friction on existing highways in which three to five site categories based on friction demand levels may be established and the corresponding intervention and investigatory levels of skid number values for each category may be determined to guide the frictional mix design.