PROJECT SUMMARY

Texas Department of Transportation

0-6255: Achieving Adequate Friction and Predicting Skid Values in Class P Concrete with Manufactured Fine Aggregates

Background

The Dallas and Fort Worth Districts use large quantities of concrete for high-traffic roadways; however, the sources of natural fine aggregates meeting the Texas Department of Transportation's (TxDOT's) minimum acid insoluble residue (AI) requirements are being depleted. The minimum AI is important to result in concrete roadways with good skid performance. As good-quality natural sand having a minimum AI of 60 percent is depleted, the Dallas and Fort Worth Districts will be required to transport natural sand from distant pits and blend them with local manufactured fine aggregate (MFA) sources. To potentially permit the use of more local MFAs in PCC pavements, the research investigated the use of AI values for fine aggregates to predict skid performance of PCC pavements.

What the Researchers Did

In the laboratory researchers tested slabs of concrete mixtures, using each of the current TxDOT-approved fine aggregates and fine-aggregate blends, as well as some non-approved blends. Physical property tests for hardness and durability using the micro-Deval apparatus (MD) and AI were run on the fine aggregates used in the program. Twenty-inch-square concrete slabs, finished with a rough broom texture on the top surface, were made from each of the fine aggregates for testing.

Slab testing involved polished under simulated traffic conditions with a three-wheel polishing device (TWPD). The device used three large, steel castors with polyurethane (shore-A durometer hardness of 85) wearing surfaces, which rotated in a 12-inch-diameter circular pattern. Weights were applied to the device to result in about 50-psi wheel loads. The slabs were polished for 160,000 cycles, or 480,000 wheel passes, which was determined to be equivalent to 700,000 equivalent single-axle loads (ESALs). The slabs were evaluated for friction with the dynamic friction tester (DFT) and for texture with the circular track meter (CTM) before polishing, after 5,000 cycles, 40,000 cycles, 100,000 cycles, and 160,000 cycles. The DFT and the CTM measured properties in the same circular wheel path as the TWPD.

The DFT and CTM were taken to the field to evaluate actual wear polishing on 12 roadway sections with heavy truck traffic (ESALs). The results from these two pieces of equipment were compared to TxDOT skid trailer data collected from those roadways at the same time to begin to correlate DFT coefficients with TxDOT skid

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trailer coefficients and to begin to establish a model for predicting service life for acceptable skid resistance on concrete pavements.

What They Found

- Laboratory evaluations (polishing with the TWPD followed by DFT readings) showed good correlation and good repeatability when compared with the critical physical properties of the MFAs and with the skid performance in the field. Loss of additional friction and textures due to TWPD weights and castors was negligible after 160,000 cycles.
- An equation to calculate the skid number based on the skid trailer using a smooth tire at 50 mph ($SN(50)_{smooth}$) was developed using values obtained by the dynamic friction tester (DFT60) at 60 kmh.
- Field test sections using limestone MFA, ranging from 40 to 100 percent of the total sand, showed that 100 percent of MFA had low skid numbers compared to blended sands. Test sections made with blended sands with only 40 percent siliceous content gave much higher skid numbers after 16 years of traffic (4.6 million ESALs).
- A reasonable correlation exists between DFT-based surface friction and AI for all aggregates and blends, except dolomites and dolomitic limestones. For AI > 60 percent, friction values were high, but even for some fine aggregates with AI < 60 percent, relatively high friction values were achieved.
- A good correlation exists between MD loss and AI for aggregates with MD less than 24 percent. Hard, fine aggregates, e.g., dolomites and dolomitic limestones, performed well when tested for friction using the TWPD.
- An alternative method to the current TxDOT acceptance procedure for use of fine aggregates in paving concrete is proposed based on micro-Deval results. This method allows harder MFAs that do not meet AI to be used at a higher replacement rate without causing reductions in skid on pavements. An MD limit of 12 percent loss is recommended for the new procedures.
- Using field and laboratory data, a model for predicting skid was established. The model allows $SN(50)_{smooth}$ to be estimated using the total ESALs and the AI or MD value of the fine aggregate.
- The model established for predicting $SN(50)_{smooth}$ was used to develop design tables to aid designers in choosing the AI or MD limits needed, based on the estimated ESALs and the approximate number of years the pavement is required to maintain a specified value of $SN(50)_{smooth}$.

What This Means

These research results will permit TxDOT to more accurately assess local MFAs and design skid-resistant concrete pavements using more local materials, which will permit more MFA used and result in less transportation of natural sands, which in turn, will result in lower cost and less pollution due to reduced transportation.

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