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Comparative Analysis of Coarse Surfacing Aggregate Using Micro-Deval, L.A. Abrasion and Sodium Sulfate Soundness Tests

http://www.mdt.mt.gov/research/projects/mat/coarse_aggregate.shtml

Introduction

Montana Department of Transportation (MDT) currently uses the Sodium Sulfate Soundness test and the Los Angeles Abrasion and Impact test (L.A. Abrasion test) to determine aggregate quality. The Sodium Sulfate test's timeliness and repeatability has been questioned by transportation officials and researchers across the country, mostly due to its known poor repeatability. As such, several other state departments of transportation have recently investigated the use of the Micro-Deval Abrasion test as an alternative for determining aggregate durability. The objective of this study was to investigate whether the Micro-Deval test will provide better, timelier and more repeatable information about the quality of Montana aggregates than the Sodium Sulfate Soundness test.

What we did

The detailed work plan developed and followed by the Western Transportation Institute (WTI) focused on two main tasks, the first of which was a thorough review of research pertaining to durability testing of aggregates. Several tests exist to determine the strength, durability and toughness of aggregates; however, information from these tests has been known to conflict. A literature review was conducted to focus on research that attempted to correlate or quantify relationships between various soil durability/toughness tests. Even though numerous durability tests have been proposed over the years; this review focused on three tests germane to this study: the Micro-Deval, L.A. Abrasion and Sodium Sulfate tests. Generally, these tests are geared toward providing information related to an aggregate's ability to resist degradation during construction and under traffic loading or to determining how well aggregates withstand environmental changes (i.e., freezing and thawing, wetting and drying).

The second main task was to conduct comparative testing on a variety of aggregates using Micro-Deval, Sodium Sulfate, and L.A. Abrasion tests to examine the repeatability of each test, and to compare test results in terms of aggregate durability and degradation. The soils examined in this study were primarily granular and cohesionless, typical of material that would be excavated and processed for use as aggregate for plant mix asphalt or crushed base course. Soil samples were obtained from gravel pits throughout the state of Montana.

For the purposes of this study, the following percent loss pass-fail standards were used for each test:

- Micro-Deval: passing (i.e., durable), if % loss ≤ 18%;
- L.A. Abrasion: passing (i.e., durable), if % loss ≤ 40%; and
- Sodium Sulfate: passing (i.e., durable), if % loss ≤ 12%.

The testing program provided data for evaluating the repeatability of multiple tests conducted on the same material (five repeats for the Micro-Deval test and three or more repeated tests for the L.A. Abrasion test) and for examining correlations between the three tests. The scope of this study did not include a repeatability evaluation of the Sodium Sulfate test; consequently, the Sodium Sulfate percent loss values were obtained from single tests on each aggregate.

What we found

Literature Review. Sixteen research studies were critically reviewed to qualitatively examine the relationships between different durability tests. Although results from the literature were at times inconsistent, some trends emerged. Most of the reviewed articles reported favorable or useful results using the Micro-Deval test. The Micro-Deval test generally was considered repeatable and it reportedly correlated well to field performance. In contrast, several studies indicated that the L.A. Abrasion test does not accurately predict field performance. The Sodium Sulfate test commonly received poor ratings in terms of repeatability and correlation to field performance. Reported research that attempted to correlate results between various test methods yielded inconsistent conclusions. Some authors suggested that a more reliable assessment of aggregate durability could be obtained by employing multiple test methods. However, specific practical implementation recommendations were not provided.

Laboratory Testing. Results from the suite of laboratory tests were normalized to facilitate direct comparisons between the three test methods. Normalized test results were obtained by taking the average percent loss for a particular soil and dividing it by the pass-fail standard for that test. Plots were generated to make direct comparisons between the Micro-Deval and Sodium Sulfate tests (Figure 1), the Micro-Deval and L.A. Abrasion tests (Figure 2), and the L.A. Abrasion and Sodium Sulfate tests (Figure 3). Data points within these plots fell within one of two regions: 1) regions where the test results agreed (i.e., pass-pass and fail-fail regions) or 2) regions where the test results disagreed (i.e., pass-fail and fail-pass regions). Linear regression of the data points and the corresponding confidence intervals were examined to aid in qualitatively assessing the degree of positive correlation between test methods.

Based on these results, the Micro-Deval, L.A. Abrasion, and Sodium Sulfate tests appear to correlate well for aggregates that have a relatively low percent loss value. Discontinuities between the three tests begin to appear with materials that have percent losses near the cutoff values. Because of the scarcity of borderline and failing tests, the statistical significance of this observation could not be quantified. The following observations are presented based on a qualitative review of the results, and the 95% confidence bands that were created through a statistical evaluation of the data.

1. The largest scatter of data occurred in the comparison between the L.A. Abrasion and Sodium Sulfate tests.
2. Of the three tests, the Sodium Sulfate appears to be the most difficult and time-consuming test to perform. This test also has the poorest record for repeatability and the poorest correlation to field durability.
3. The Micro-Deval test tended to provide more “conservative” results than the L.A. Abrasion and Sodium Sulfate tests.
4. Aggregates that pass the Micro-Deval test will likely also pass the L.A. Abrasion and Sodium Sulfate tests.
5. Based on the 95% statistical confidence bands, the authors suggest that the greatest likelihood of pass-fail conflicts will occur when the percent loss of a sample is slightly greater than the Micro-Deval cutoff criteria.

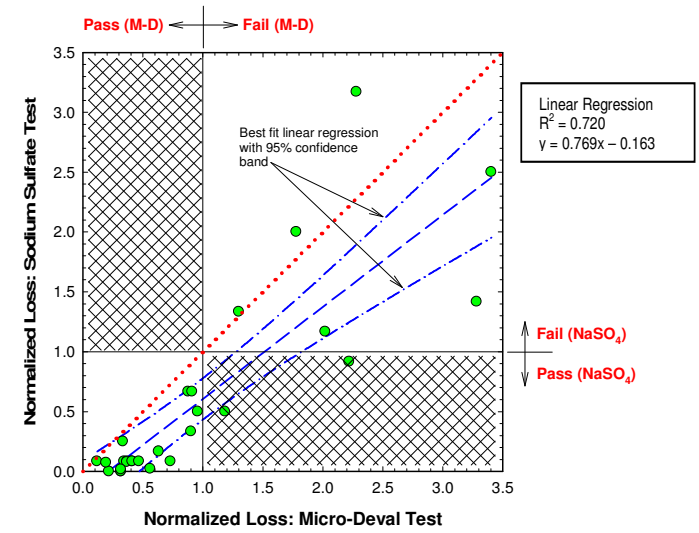

Figure 1. Normalized comparison between Micro-Deval and Sodium Sulfate tests.

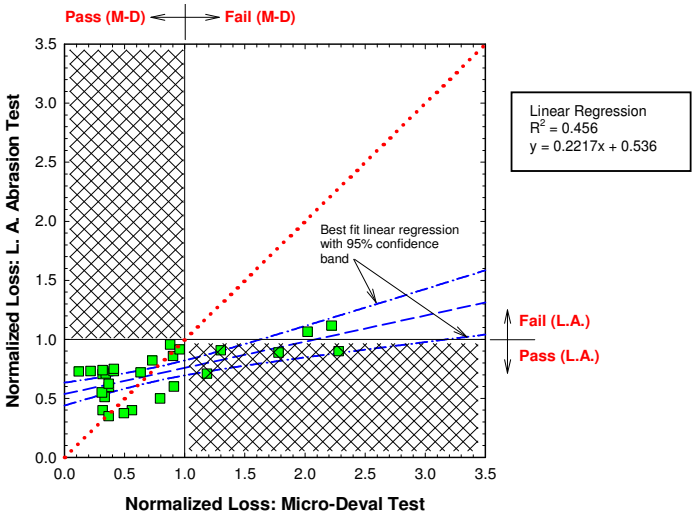

Figure 2. Normalized comparison between Micro-Deval and L.A. Abrasion tests.

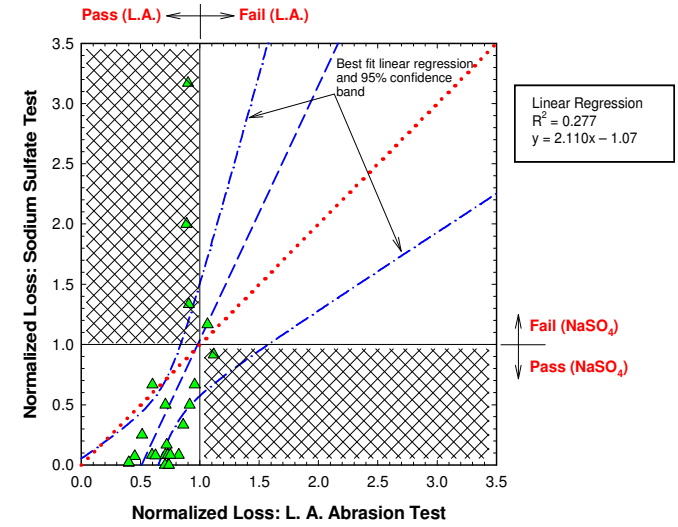

Figure 3. Normalized comparison between L.A. Abrasion and Sodium Sulfate tests.

What the researchers recommend

The researchers conclude that the Micro-Deval test is a suitable replacement for the Sodium Sulfate test as the primary test for evaluating aggregate durability. However, because there were some inconsistent durability determinations between test methodologies, the researchers recommend that the Micro-Deval test results be further supported by a second aggregate durability test whenever the Micro-Deval results slightly exceed the cutoff value of 18 percent loss. The researchers define slightly exceed as a test result that falls between the cutoff value and plus 30% of the cutoff value. In other words, when the Micro-Deval test result for an aggregate is between 18 and 24 percent loss, a second test should be conducted before any conclusions are made regarding the durability or quality of an aggregate. Suggested alternative tests include recognized methods such as the Sodium (or Magnesium) Sulfate Soundness test or the L.A. Abrasion test. The authors suggest additional research to further establish appropriate cutoffs for these tests as well as a field study to relate the results from these index tests to field performance.

For More Details . . .

The research is documented in Report FHWA/MT-06-016/8117-27, *Comparative Analysis of Coarse Surfacing Aggregate using Micro-Deval, L.A. Abrasion and Sodium Sulfate Soundness Tests*.

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MDT Implementation Status
February 2007

MDT has reviewed the Western Transportation Institute's (WTI) research and concluded the Micro-Deval test is a suitable replacement for the Sulfate Soundness test when evaluating aggregate durability. MDT is in the process of developing an implementation strategy to transition from the Sulfate Soundness test to the Micro-Deval for aggregate source approval. The new specification will essentially follow the recommendations provided by WTI.

The Department is working to develop the necessary specifications and procedures. The implementation process will be presented to the contracting and consulting communities for comment prior to implementation. MDT anticipates including the new specification in all contracts starting with the May 2007 letting. A transition period of one year is expected.

For more information contact Matt Strizich, mstrizich@mt.gov, 406-444-6257 or Scott Barnes, sbarnes@mt.gov, 406-444-6267.

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