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EVALUATION OF AGGREGATES FOR BASE COURSE CONSTRUCTION

PROBLEM STATEMENT

Research into the characterization of carbonate materials used for highway construction in Florida is of great interest to the Florida Department of Transportation (FDOT). As new quarry locations are opened and new materials are used, it becomes increasingly important to carefully monitor these materials to insure that proper specifications are being met. Recent studies of base course materials constitute one among many areas of focus.

Currently, no laboratory tests are used by the FDOT to quantify or predict strength and stiffness gains that could be generically applied to a range of material types. There is a need to quantify potential increase in performance characteristics of an aggregate base and to identify the causal physical/chemical characteristics of the aggregate. There also is a need to investigate other laboratory test procedures that might be useful in supplementing the Limerock Bearing Ratio (LBR) test. These tests could be used on low-cohesive materials or on water-sensitive materials to estimate constructability or durability issues to which the LBR test may not be adequately sensitive.

OBJECTIVES

1. To develop and evaluate test procedures for the evaluation of base course materials (not currently specified) based on generic, measurable engineering properties and not based on limited chemical or mineralogical criteria. These measured properties will include aggregate properties and predictions of strength gains over varying time periods using methodologies reported in the technical literature and of practical use to the FDOT.

2. To evaluate the performance of these new tests on current and proposed aggregate sources and aggregate substitutes, including recycled products, to determine the acceptance of these materials for use as base materials in traditional roadway designs, specifically to ensure conformance to AASHTO design requirements.

3. To test selected materials used in current and/or previous field construction projects.

FINDINGS AND CONCLUSIONS

Results of the study are as follows:

1. The effect of strength gain by cementation (carbonate content versus LBR) was not statistically significant in either part of the LBR portion of this study, and no equations predicting LBR results based on carbonate content were produced that were statistically significant. Test results indicated that variability in LBR values, over various time periods of up to 60 days, impacted the analyses. Consequently, dry density (γ_d) was the only significant factor affecting the LBR values, primarily in the untreated samples, in Part 1 of the LBR study. In Part 2, the only correlation observed with

LBR data seemed to be material gradation; however, that was found to be a statistical artifact of the gradation of MX411. When MX411 was excluded from analysis, no correlation was found to exist among the Florida materials tested. Dry density was held more constant for the samples used in Part 2 and, therefore, was not found to impact LBR results as much as was observed in Part 1. LBR data for treated samples (1 percent lime) from Parts 1 and 2 also showed the most statistically significant correlations to gradation, although the correlations in Part 2 were again an artifact of MX411.

2. Triaxial shear tests were inconclusive. The effect of time on strength gain of lime treated aggregates was minor, although the lime treatment appeared to produce a small increase in the angle of internal friction (Φ). Tangent moduli derived from these tests gave no indication of time-dependent effects, although the moduli for lime-treated aggregates were in all cases slightly greater than for untreated aggregate.

3. Resilient Moduli (M_R) test results were consistent with aging time having no apparent effect on the test results for aggregate from all the pit locations tested. These results, combined with FDOT data from prior tests on seven other aggregates, were analyzed to determine AASHTO structural design coefficient a_2 for sum of principal stresses (Θ) equal to 137.9 kPa (20 psi). Values of a_2 ranging from 0.15 to 0.22 were obtained, which were similar to the range (0.16 to 0.23) of 10 different bank-run shell specimens.

4. Limited tests performed using the Gyratory Testing Machine (GTM), equipped with air roller, gave lower gyratory shear (G_s) strength with lime treated Pit 36-246 high carbonate aggregate than the with untreated aggregate. Conversely, low carbonate (44%) aggregate from Pit 70-279 produced higher shear strength for the lime-treated aggregate. The effect of density was not apparent except for lime-treated aggregates from Pit 56-465, which showed a substantial increase in shear strength with densification. Apparently, this material most likely contained clay, which may have reacted to the lime treatment. A tentative relationship between the G_s and the M_R values was developed and used to establish a prediction equation for a_2.

5. Researchers hoped to develop a rapid and reliable technique to accelerate cementation of limestone base course materials in order to predict increases in field-based strength performance through experimenting with a total of eleven autoclave-based treatments of prepared test specimens. Unconfined compression tests (UCT) performed on both high carbonate (Pit 36-246 and Pit 56-465) and low carbonate (Pit 70-279 and Pit 93-406) materials were undertaken as a means of undertaking and evaluating this technique. However, average failure stress values showed no correlation to aggregate carbonate content or to the other engineering parameters measured over the short time spans tested in this study. However, untreated samples showed greater strength gains in almost all experiments.

RECOMMENDATIONS

The differences in aggregate gradation, particle shape and texture, clay and silt content, moisture content, and compacted or in-place density precludes the use of generalized characterization for determination of structural coefficients or behavior. The triaxial resilient modulus is a time consuming but reliable test method. The GTM has the advantage of providing G_s data throughout a range in density, which makes it a quick and efficient method for testing aggregates with different moisture contents.

Researchers recommend that FDOT consider a study to verify or modify the M_R and a_2 prediction equations based upon G_s test values. This effort will require a comprehensive test program involving aggregates from different pits, modification of aggregate blends and gradations, different moisture contents, and different density levels to ascertain the effect of variables and to develop a reliable relationship using G_s or other aggregate characterization variables.

In the interim, aggregates having long-term strength gain potential should be considered on the basis of as-placed, short-term properties. Test results imply that carbonate content is not necessarily the parameter that relates to the strength gain in structural properties or bearing capacity of limestone base course aggregates. If it is assumed that M_R calculation of a_2 is reliable, then to what degree will testing variability and differences in density/moisture content affect this value and behavior of the pavement? Until further research is performed, researchers suggest that an a_2 value of 0.18 for Θ = 138 kPa be used for these materials conforming to FDOT specifications.

LBR testing also may offer a good method for evaluating the importance of carbonate content to base course strength gain phenomena. However, test variables observed in this study may require that individual lithologies be independently evaluated because carbonate content has a variable meaning for different materials around the state. The role of aragonite content and gradation within the context of cementation and/or base course strength gain should also be evaluated.

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