Summary of Final Report, Contract# PR231460
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ACOUSTIC AND STRUCTURAL DYNAMIC DIAGNOSTIC EVALUATION OF RIPRAP

BACKGROUND

The Florida Department of Transportation (FDOT) needs an enhanced procedure for speedily evaluating the integrity and durability of Riprap boulders other than the Sodium Sulfate Soundness test, which is time consuming. Research is needed to evaluate a technique that uses analysis of sound waves to evaluate the material. Multiple specimens can be immediately analyzed for acceptance.

By its very size, Riprap has been a difficult item to produce and stockpile in mines. Generally, the manufacturer is under contract with the mine to dispose of large boulders that cannot be run through the plant because of cost constraints attributed to their size and hardness. As a result, Riprap is produced upon order and can thus become a serious threat to the critical path schedule of placing bridge beams above embankment slopes. Any method that can speed the approval process of production stockpiles would be welcomed by both District Materials groups and Contractors.

FDOT has sponsored previous research to evaluate the physical properties of Riprap boulders, specifically with regard to conventional laboratory soundness tests such as Sodium Sulfate Soundness, Gyratory strength, Iowa Pore Index Testing, Mercury Porosimetry, and Petrographic analysis. However, no research had been performed on the potential for acoustic analytical approaches.

OBJECTIVES

The specific objectives of this project included the following:

1. To demonstrate the sensitivity and ability of acoustical analyses methods to characterize material properties.
2. To develop a rational approach for evaluating responses from Riprap materials and using acoustical analysis in evaluating Riprap durability.
3. To develop a procedure for performing tests in the field.
4. To develop a system that quantifies a response of materials with known performance.

FINDINGS AND CONCLUSIONS

The researchers performed acoustic impact-emission tests, Windsor Pin System® tests, and impact frequency response functions on Florida rock samples to identify causal relationships existing between measured responses and the samples' petrographic characteristics. Researchers used regression analysis to relate measured responses with aggregate properties strongly affected by chemical and physical weathering. Aggregate properties such as mineralogy, porosity, and grain size were identified in thin section analyses performed by consultant geologists.

The identification of causal relationships is necessary to satisfy a transfer function model of a durability test for aggregate used in civil engineering applications, namely bank and shore protection.

Strong relationships proved to exist between Windsor Pin System® measurements, impact frequency response functions, and some aggregate properties for samples originating from the same quarry. Researchers used similarities and differences in the relationships to evaluate the feasibility of the applied methods, such as durability assessments and present considerations for future research of aggregate performance.

Researchers examined petrographic weighting factors developed during the study, comparing them to previously attempted methods of evaluating aggregate durability. Inconsistencies observed between petrographic number determinations and the results of currently employed durability evaluations for the samples studied in this investigation suggest that the factor weights need to be re-evaluated for Florida aggregates. However, there is insufficient data to make specific recommendations on how to best improve the petrographic number technique and the assignment of factor weights to the various mineralogical and textural components of the samples.

BENEFITS

The Department plans to implement a pilot study using the findings from this study. The State Materials Office (SMO) will gather data on large field samples from various mines and field sites. Results will be used to compare the variability established in this study with stockpile variability. This will permit the establishment of calibrations for individual sources.

Implementing the option of “calibrating” stockpiles of riprap and testing subsequent stockpiles using the developed methodology could shorten approval time for riprap from one and a half weeks to about one day. Faster approval of riprap will permit faster construction schedules for projects on which riprap is placed under girders at bridge approaches. While there would be up-front costs to purchase microphones to apply the acoustic analysis approach, the ultimate result would be moderate cost savings by reducing the frequency of materials tests such as sulfate soundness.

In addition, SMO intends to establish a training site where personnel can learn to recognize responses from different material types. The acoustic measurements will be used to train personnel on selecting samples for additional laboratory testing.

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