Research Project: SHA/MSU/4-2
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RESEARCH SUMMARY

Validation of Source Approval of HMA Surface Mix Aggregate

Problem

Pavement surfaces must maintain an adequate level of friction in order to provide a safe surface for vehicles. The Maryland State Highway Administration (SHA) is responsible for ensuring that flexible pavement construction, using hot mix asphalt (HMA), meets approved skid resistance standards, by selecting surface mix aggregate with adequate frictional and durability characteristics. Conventional aggregate testing methods are however, laborious, time-consuming, and expensive. This research proposed to develop faster, accurate, cost-effective, and nondestructive methodologies that utilize spectral properties and characteristics of aggregate samples such as their wavelength and reflectance to assess and evaluate HMA surface mixes.

Objective

The objectives of this research were to develop and utilize spectroradiometric methodologies including Chemometrics and Neural Network (NN).These methodologies will develop a spectral library that SHA will utilize to characterize and validate the original source of HMA surface mix aggregates.

Description

Two different methodologies were employed in this Project: 1 – Grams IQ Chemometrics Method and 2 – Neural Network (NN) Method. This multi-pronged approach, when proven, will undoubtedly offer the SHA options and flexibility in selecting the appropriate methodology for validating aggregate source and to some extent determining their properties. The FieldSpec 4 spectroradiometer (FS4), developed by Analytical Spectral Devices (ASD), and now known as PANalytical was utilized in this project. The FS4 is recognized as one of the best portable high-resolution spectroradiometers for a wide range of scientific and engineering applications. Its 3-nanometer (nm) Visible-Near Infrared (VNIR) and 8 nm Shortwave Infrared (SWIR) spectral resolutions provide excellent spectral performance across the full range of electromagnetic spectrum (EMS) – (350 – 2,500 nm). These spectral resolutions make it possible to detect and identify a wide variety of geospatial features and their elements/compounds. A total of 42 aggregate samples from 19 different quarries were provided by the SHA to Morgan State University (MSU) for analyses using the FS4.

The samples were kept in the lab, in glass jars, under normal temperature and dry conditions. In order to maintain confidentiality of the quarries, identification numbers (IDs) were assigned to each of the samples. Great care was taken during the handling of each and they were returned to their respective jars after the spectra extraction were completed. The apparatus use to complete the testing is shown in Figure 1 below.

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Figure 1. ASD FS4 Setup: (A) – FS4, (B) – Computer Control, and (C) – ASD Turntable.

Results

Chemometrics methodology using discriminant analysis, calculated from reflectance data at full wavelengths (400-2,450nm) was able to discriminate limestone found in a particular quarry location from other aggregates derived from different quarry locations. When applied to a data set, it appears that the two classification models correctly identified the samples not related to the original data population. The results from the spectra identification and pattern analysis could be used for detecting and explaining the variability in the frictional and physical properties of aggregates within a quarry over a period of time. The spectra can be used as a quality control tool to reveal if the aggregate is from a previously known source. NN was extremely quick in estimating aggregate parameters; in some cases, it took just a few minutes including accurate parameter estimates of SG, LA coefficient, and Friction Category. The challenge however, of the NN methodology is that like most statistically based estimators it requires a large dataset, which span the extremes of all the particular classes. It is evident from the results that, once verified, these spectrometric methodologies could be used to significantly reduce the amount of time spent by SHA in analyzing aggregate samples and extract their attribute parameters.

Report Information

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Link to Final Report

http://www.roads.maryland.gov/OPR_Research/MD-16-SHA-MSU-4-2_Validation-of-Source-Approval-of-HMA-Surface-Mix-Aggregate-Using-Spectrometer_Final%20Report.pdf