0-6444: Treatments for Clays in Aggregates Used to Produce Cement Concrete, Bituminous Materials, and Chip Seals

Background

The clay contamination of coarse and fine aggregates and its effects on pavement performance of portland cement concrete (PCC), hot-mix asphalt (HMA), and chip seals are major concerns for the Texas Department of Transportation. This study:

- Determined what type and concentration of clay mineral will result in poor pavement performance.
- Identified a quick field test method to detect the presence of deleterious clay minerals in the aggregate stockpiles.
- Suggested remedial techniques to make the clay-contaminated aggregates acceptable for use.

What the Researchers Did

Researchers identified the modified methylene blue (MMB) and x-ray diffraction (XRD) tests as the most promising methods to identify and quantify clay mineral in aggregate fines. Nearly 30 aggregate sources have been tested using the MMB test. XRD was used to determine the content of different clay minerals present in these samples. XRD is an advance research tool, which was used to validate the MMB test. The correlation between methylene blue value (MBV) and concrete performance testing (both PCC and HMA) became the basis to assign a threshold MBV (corresponds to the maximum permissible clay content within the aggregate fines) and categorize aggregate fines with different ranges of MBV. The use of cationic surfactants was studied as a remedial technique for PCC. The guidelines for controlled use of aggregate fines with varying levels of clay contamination have been developed, and further research or an implementation plan has been proposed.

What They Found

A strong positive correlation between expansive clay content and MBV was evident, indicating that the MMB test is the most reliable and rapid test method to detect clay minerals in aggregate fines. The MMB test can be performed on aggregate fines passing both No. 4 (P4) and No. 40 (P40) sizes. MBV shows a good correlation with both percent reduction in strength and increase in shrinkage of the PCC mixtures with clay contamination (both pure clays as well as clay-contaminated stockpiled materials). The relationship between MBV and flexural strength was used to assign a threshold MBV of 4.5 for P4-size materials or 11 for P40-size materials.

Although the bar linear shrinkage test (Tex-107-E) and sand equivalent (SE) test

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(Tex-203-F) give good repeatability in the results, these tests fail to provide consistent and accurate indications of clay minerals present in aggregate fines. The SE test fails to distinguish between clay-sized particles and actual clay minerals. Furthermore, the SE test is not effective to differentiate between expansive (e.g., smectite) and non-expansive (e.g., kaolinite) clay minerals.

The HMA mixtures with added pure smectite clay show both poor cracking resistance and poor rutting performance. The mixtures with added kaolinite, on the other hand, had inadequate cracking performance at the higher clay levels, but good moisture susceptibility and rutting values were obtained. The pass/fail situation based on the HWTT was inconsistent with the specification limit of 45 percent minimum SE. The same is true for the results of the bar linear shrinkage test. The methylene blue test is sensitive to clays, which contribute to stripping in HMA and could be used to eliminate problematic field sand sources. Based on the pass/fail HWTT results, a preliminary threshold MBV of 7.2 mg/g with a corresponding SE threshold value of 55 percent is proposed. It appears that HMA is more robust and can tolerate higher amounts of clay contamination than PCC, mainly because water is not present in HMA.

What This Means

The MMB test method provides a rapid and reliable field method for determining changes in the quality of aggregates during production or placement. A high MBV (i.e., above the threshold ranges) indicates increased potential for diminished aggregate performance in asphalt, concrete, and other construction applications. Based on the MMB test, materials that are failed by the current specifications (e.g., aggregate fines with clay-size non-clay mineral particles) can be allowed, which promotes sustainability and saves money. The MMB test has the ability to correctly identify the problematic materials that need remedial measures. Type and concentration of clay minerals present in aggregate fines, rather than total fine content, are the determining factors for pavement performance. The MBV ranges are arbitrary in nature at this time because these are based on the MBV of limited stockpiled materials. A large number of aggregate stockpiled materials need to be tested for their MBV in both −4 and −40 sizes along with corresponding PCC/HMA performance testing in order to assign more accurate MBV ranges. The MMB test could allow the design of an optimum quantity and type of anti-stripping additive for a particular HMA (instead of common practice, i.e., 1 percent lime). Similarly, the MMB test can be used to determine the optimum dosage of cationic surfactants for PCC mixtures. The use of cationic surfactants was found to be useful as a remedial technique in PCC.

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