TECHNICAL SUMMARY

Stabilization Techniques for Reactive Aggregate in Soil-Cement Base Course

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INTRODUCTION

Winn Rock, a Louisiana aggregate quarried in Winn Parish, has been used quite extensively in the past by local and parish governments near the quarry for aggregate surface courses on unpaved roads. The Louisiana Department of Transportation and Development (LADOTD) also used it for shoulder surface course in some rural highways. As some of these parish roads were later taken into the LADOTD owned and maintained system, they were overlaid with asphaltic concrete or received asphalt surface treatment as a means of improvement. These roads have reached a point where rehabilitation is required.

The primary rehabilitation process entails stabilizing the existing base course with portland cement and constructing an asphaltic concrete overlay. Bases that contain Winn Rock have experienced heaving after the portland cement stabilization process. Often this has occurred within a day of treatment, but sometimes the expansion may not show up for months.

OBJECTIVE

The objectives of this research are 1) to identify the mineralogical properties of soil-cement bases which have heaved or can potentially heave, 2) to simulate expansion of cement-stabilized soil in the laboratory, 3) to correlate expansion with the microstructural and mineralogical properties of Winn Rock-containing soil after cementitious stabilization, and 4) to identify cost-effective stabilization agents for soils that contain Winn Rock.

RESEARCH APPROACH

Representative soil from the affected area was obtained from DOTD. In the laboratory, 2” x 4” molds of Winn Rock-containing soil were stabilized with various cementitious mixes and cured in a 40°C water bath, in a 100 percent-relative-humidity room, sealed in a plastic bag at room temperature, and in air. The mixes contained 5 percent to 20 percent cementitious material. The cementitious materials were Type I Portland cement, lime, and supplementary cementitious materials such as granulated blastfurnace slag (BFS), Class C fly ash, silica fume and amorphous silica. The expansion of the specimens over time was monitored. Mineralogical and micro-structural analysis of the specimens were performed over time and correlated to expansion. The characterization methods included X-ray diffractometry, thermal analysis, and scanning electron microscopy.

CONCLUSIONS

Winn Rock was used as gravel to improve the strength of the roads around Winn Parish, Louisiana. Over time, both mechanical and chemical weathering of Winn Rock occurred. The mechanical weathering resulted in the breakdown into smaller anhydrite grains in the finer size fractions of the soil. The chemical weathering resulted in the formation of gypsum, which was found in all size fractions of the soil in significant amounts. Apart from anhydrite and gypsum, the other sulfate phase in the soil is ettringite, which was derived from the cement from the previous attempt at stabilization.

Expansion occurs due to the formation of very small ettringite crystals. These evolve in size over the first few days. When a cement component is present in the stabilization mix, the ettringite crystals appear within an hour of mixing and do not vary much in size.

In the laboratory, expansion of Winn Rock-containing soil observed in the field can be simulated with stabilization by making cementitious mixes that have high cement contents and are cured in a high moisture / high temperature environment.

The sulfate necessary for the expansive reactions in the Winn Rock containing soil is mainly provided by gypsum because of its higher solubility and much higher dissolution rate than anhydrite. Abundant free calcium hydroxide is necessary for the expansive reaction. The addition of a supplementary cementitious material to the cementitious mix reduces the available calcium hydroxide for the reaction and thus reduces the amount of expansion.

Cement:BFS mixtures, in 1:1 to 1:3 ratios, can reduce the expansion significantly, but some expansion still does occur. The reduction in expansion is in direct proportion to the amount of BFS. When silica fume or amorphous silica is added to the stabilization mix, no expansion is observed even when cured in a high humidity and high temperature environment.

The most cost-effective mixture is a 1:3 Cement:BFS mixture. Even at 40ºC curing in a water bath, it produced less than 0.1 percent expansion. The addition of silica fume to this mixture will reduce expansion to below detection limit, but will increase the cost of stabilization by 50 percent compared to the blended cement mixtures.

RECOMMENDATIONS

Laboratory tests showed that cementitious mixes with supplementary cementitious materials are effective in reducing expansion of sulfate-containing soils. Instead of pure Portland cement, blended Portland cement and granulated blast-furnace slag should be used for stabilization of Winn Rock-containing soil.

The cheaper price of BFS-blended cement may make its wider use possible without any reference to sulfate attack. Just like Portland cement concrete, the use of blended cement can confer improved properties to the stabilized soil.

Full-scale test sections should be built to test this hypothesis in the field.

The effect of variable moisture content on expansion should be studied. Specimens should be initially stored in a low humidity environment, followed by a high humidity environment.