TECHNICAL SUMMARY

Long Term Evaluation and Identification of the Proper Testing Program for ASTM Class C Fly Ash Stabilized Soils

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INTRODUCTION

The potential for stabilizing coarse and fine-grained soils in the construction of subgrades, subbases, and bases for pavements with ASTM Class C fly ash has been demonstrated. However, previous studies with locally produced ASTM Class C fly ash have emphasized the importance of the testing method and the criteria used in evaluating their performance as stabilizing agents. These studies have demonstrated an incompatibility with respect to some of the current test procedures, field placement methods and the materials' properties. Current Louisiana Department and Development test procedures and criteria for lime and cement treated soils are inadequate in analyzing fly ash as a stabilizing agent replacing lime or cement. Test criteria used for cement stabilized soils do not account for the long-term pozzolanic potential of a lime-fly ash mix nor the flash set reported to occur in some Class C fly ashes. Also, existing lime treatment criteria as used locally address only soil modification of plastic clays.

The incompatibility of some of these test procedures with the sequence of chemical events taking place with Class C fly ash demonstrates a need for further evaluation. There has been noted a deterioration in some fly ash mixtures that has not been previously reported. Routine tests currently utilized by the Louisiana Department of Transportation and Development do not fully evaluate the Class C fly ash as a stabilization agent.

OBJECTIVES

The objectives of this research were to further evaluate the characteristics of locally produced fly ash and to develop test procedures which would expedite the evaluation of fly ash stabilized soils. Because cement and lime stabilization techniques are well established, comparisons of fly ash stabilization methods with these materials were also necessary.

To accomplish this, information on other tests currently being performed were reviewed, tested and evaluated to determine their applicability. A test approach is proposed for evaluating the fly ash potential as an alternative to other conventional materials and methods.

Long term effects are also addressed to determine whether there is continued strength gain or possible deterioration with time.

RESEARCH APPROACH

The variables involved with fly ash stabilization are numerous and thus, were limited to meet the objectives. The testing variables included: mix design criteria, mixing sequence, curing methods, and test specifications.

A review of current practice and a laboratory test program were conducted in an evaluation of the protocol used for soils stabilized with Class C fly ash. The long-term performance of soils stabilized with Class C fly ash was also reviewed. The test program included an evaluation of material properties as well as mix design methods with their corresponding testing requirements. X-ray diffraction and electron microscopy were performed in reviewing the long term variations in strength and the effects of curing conditions on the cementitious products being formed. The study reviews the unique physical properties that influence the development of strength. The relationship between gradation characteristics, density, compaction water, and strength are explored.

In this research, an A-3 sand and a bentonite clay were the soil types used. The stabilizers used with the sand were cement, fly ash, and mixtures of lime and fly ash. In all cases, mixing was performed in the same manner, with the materials being mixed dry before any moisture was added. Mix design criteria from various sources, including state practices, were examined. Various percentages of stabilizer to soil were limited by practicality, time, and cost. Normal curing methods were used along with an accelerated method. Standard and other research tests were conducted to evaluate the materials performance under different conditions.

CONCLUSIONS

A unique relationship exists between maximum dry density, optimum moisture, and the percentage of fly ash used with sands. For a given compaction effort, the largest dry density possible corresponds to the least amount of compaction water, i.e., smallest optimum moisture content. Strength curves produced for the different percentages of Portland cement or Class C fly ash (alone) showed promise as a guide for predicting the percentages of fly ash required to produce comparable strengths developed with soil-cement. In reviewing the compaction method and specimen types, either the Proctor method or Texas method specimen sizes are perceived as being acceptable.

The 1-day accelerated cure (50^{o} C) strength provides an acceptable prediction of the 28-day strength under normal cure conditions for the lime-fly ash-bentonite mixture. The 1-day accelerated cure is not indicative of the strength potential for any curing period used with the lime-fly ash-sand mixture.

The fly ash in this study definitely has a flash set. The set occurring in laboratory tests varied with different sand sizes. The final set time occurring with the fly ash in a coarse sand took place in 15 minutes. The fly ash set time in a fine, somewhat silty, sand was approximately 85 minutes. Strength tests after delayed compaction were significantly reduced with as little as a one hour delay.

There is a distinct long term advantage in using lime with the Class C fly ash in a sand or coarse aggregate. The strength development is slow for the first 7 days. Thereafter, the gain in strength is rapid.

A decrease in the modulus of elasticity of the lime-fly ash-bentonite clay makes its long term performance questionable. The dissolution of the fly ash grains with longer cure periods similar to that observed in previous research was also noted in this study.

If Class C is to be used effectively, its unique characteristics must be understood. Some of the attributes attributed to Class C fly ash can be misleading or may be detrimental if ignored. A hit-or-miss end product will result by using it blindly.

RECOMMENDATIONS

Class C fly ash has excellent properties that make it a versatile construction material. It should be considered for general use in soil stabilization. It can contribute greatly in situations where natural, high quality aggregates are unavailable.

A relationship of comparable strengths produced between Portland cement and an equal amount of the CaO constituent in the Class C fly ash is proposed as a design guide. The curing requirements for the strengths produced in different mixtures varied. Curing time and conditions are recommended on the basis strength development. A distinct long-term advantage was observed in using lime with the Class C fly ash in sands and coarse aggregate.