LOUISIANA TRANSPORTATION RESEARCH CENTER
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Evaluation of Fly Ash Quality Control Tools

INTRODUCTION

Many entities currently use fly ash in portland cement concrete (PCC) pavements and structures. Although the body of knowledge is great concerning the use of fly ash, several projects per year are subject to poor performance where fly ash is named as the culprit. Generally the "bad" projects arise due to:

1. Poor understanding of how fly ash affects concrete pavement construction and performance or
2. A switch of fly ash sources midstream during the construction project.

This project was initiated to develop tools for quality control purposes for as-delivered class C fly ash. A good quality control tool would help contractors gain an understanding of the fly ash, its variability, and how it may affect the resulting concrete.

OBJECTIVE

The objective of this research was to identify tools available for quality control (QC) of as-delivered class C fly ash. The main focus of the research was to identify penetration type devices and test procedures including the Iowa Set Time Test, Gillmore Needle, and Vicat Needle. Another focus of the investigation was the quick heat generation index test.

SCOPE

For the first objective, three penetration type test devices were investigated including the Vicat needle, Gillmore needle, and pocket penetrometer. Class C fly ash samples were obtained from about 10 sources available to Louisiana Department of Transportation and Development (LADOTD). Statistical analysis was completed on the results from each bucket as well as each source.

The second objective was to indentify if the quick heat generation test can identify small changes in class C fly ash whether that be a change in chemistry or a physical change in the fly ash fineness. Statistical modeling was used to determine if a relationship existed between the various initial and final set times and the maximum temperature of the fly ash paste and the fly ash chemistry and fineness.

LTRC Report 469

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A third objective was added during the course of the study to examine the set time effects when fly ash with high variations in set time are added to cements with a 50 percent addition rate.

METHODOLOGY

Ten sources of class C fly ash and one high calcium class F fly ash available in the state of Louisiana were chosen for this study. Each fly ash source was sampled, five gallon bucket size, by the producer twice weekly for a period of 10 weeks totaling about 210 individual samples.

Each bucket of fly ash was chemically characterized according to ASTM C 618. Set time tests included a modified ASTM C 191, modified ASTM C 266, and the Iowa Set Time Test. The quick heat generation index test determines the heat liberated due to hydration of cementitious materials.

Two sources were chosen to compare the fly ash only set time results to the set time of a fly ash–cement combination. Fly ash and cement were combined at the rate of 1:1 and the set time was compared. Statistical analysis was used to determine if there was any significant difference between sample results, and statistical modeling was used to determine if a relationship existed between the set times, chemistry, and temperature effects.

CONCLUSIONS AND RECOMMENDATIONS

The Gillmore needle, Vicat needle, and pocket penetrometer yielded similar results when observing the times to the initial and final set across the three test methods; therefore, any of these devices may be used to determine set time. Although all test methods pointed out significant differences in set times between buckets within a source, those differences were mitigated when incorporating portland cement into the sample. In other words, blending fly ash with portland cement normalized the set time of the fly ash, even from a source exhibiting high variability in set times when incorporated at 50 percent.

The temperature results showed that the coffee cup test method is unable to be used as either a quality control or quality assurance device in characterizing class C fly ash. The statistical analysis results showed outliers within the sources, but further testing when incorporating portland cement showed these differences to be negligible. A suitable correlation was found to exist between the calcium oxide and sulfur trioxide content and the maximum temperature of the fly ash temperature results.

The results of this study indicate that the hydration of class C fly ash is a complex phenomenon that cannot be fully described by the tests used in this study. It is recommended that if the Department wants to further define the relationship between fly ash chemistry and fly ash set time, another study be undertaken to look at the tricalcium aluminate content and its role in hydration characteristics of class C fly ash. The results of this study also show that the current practice of requiring field set time tests conducted in the field are adequate and should be continued in quantifying field variations of set time.