Influence of Powder Activated Carbon (PAC) in Fly Ash on the Properties of Concrete

Evaluation of the impacts (air voids and expansion properties) of PAC-containing fly in air-entrained concrete

Project Number:
19CASU03

Start Date:
08/15/2019

End Date:
02/15/2021

Principal Investigator(s):
Zahid Hossain
Arkansas State University
mhossain@astate.edu

Lead Institution:
Arkansas State University

Funds Requested to UTC:
$38,500

Funding Source(s):
Tran-SET
Boral
ACPA
NEAR Concrete

Total Project Cost:
$77,000

Class C Fly Ash (CFA) is routinely used by contractors as a partial replacement of Ordinary Portland Cement to produce concrete. However, the Arkansas Department of Transportation (ArDOT) is concerned about certain CFAs as they contain powder activated carbon (PAC). The main objective of this study is to assess the influence of PAC in fly ash on the properties of concrete. Specifically, it will develop guidelines controlling the PAC in fly ash to be used in concrete. This will be accomplished through a comprehensive review of available literature and experience of other states, and extensive laboratory testing of selected fly ashes. Fly ash samples will be collected in consultation with ArDOT engineers, ready-mix contractors, and fly ash suppliers. Fresh concrete will be prepared in the laboratory to determine air-content. Hardened concrete will be tested for expansion properties. Data collected from laboratory tests will be analyzed and summarized to provide implementation recommendations to ArDOT.

This study will quantify the increase in demand of the air-entraining agent (AEA) in producing durable concrete. A higher amount of large entrained air bubbles due to the addition of fly ash can lead to the reduction in the volume of the entrained air bubbles during the service life of the concrete. Furthermore, the spherical shape of fly ash is found to cause a larger rate of reduction in the volume of the entrained air bubbles as the coalescence and escape of entrained air bubbles can easily occur. The degree of coalescence of air bubbles can be reduced by careful selection of the AEA and the mixing procedure. Alternatively, the unburned carbon can be reduced or removed by a high-temperature burnout or separated physically. To separate carbon from ash, additional steps such as froth flotation process can be adopted. Such knowledge and techniques do not exist in the public domain today. The current study aims to reduce this knowledge gap.

Problem Statement

Ready-mix concrete contractors in Arkansas routinely use Class C Fly Ash (CFA) as supplementary cementitious material (SCM) in producing concrete. The CFA is used as a partial replacement of Ordinary Portland Cement (OPC). Thus, the CFA must meet certain ASTM requirements (e.g., carbon content, loss of ignition) before it can be used in producing concrete. However, ArDOT is concerned about some CFAs as they contain power activated carbon (PAC), which creates adverse impacts on the target aid voids and post-construction durability of air-entrained concrete. The PAC in fly ash increases the demand of the air-entraining agent (AEA) used to achieve specified air content. A higher amount of large entrained air bubbles due to the addition of fly ash can lead to the reduction in the volume of the entrained air bubbles over a period of time. Furthermore, the spherical shape of fly ash is found to cause a larger rate of reduction in the volume of the entrained air bubbles as the coalescence and escape of entrained air bubbles can easily occur. The degree of coalescence of air bubbles can be reduced by careful selection of the AEA and the mixing procedure. Alternatively, the unburned carbon can be reduced or removed by a high-temperature burnout or separated physically. To separate carbon from ash, additional steps such as froth flotation process can be adopted.

In a recent ArDOT Research Roundtable meeting, roadway engineers mentioned about CFA produced in plants of some specific suppliers are known to have PAC, which creates a problem for the agency. The same issue is also applicable for some Class F Fly Ash. The ArDOT needs a tool and/or technique to quantify the PAC in fly ash so that the fly ash can be accepted/rejected in construction jobs. Further, it is intended that the supplier(s) can take necessary measures so that the PAC level is controlled at the CFA plant. In addition, special provisions can be included in the quality control/quality assurance guidelines for the ready-mix plants for using fly ash with PAC in preparing concrete.

Objectives

The primary objective of this proposed research project is to assess the influence of PAC in fly ash on the properties of concrete. Specific objectives of this study are: (i) know the amount of PAC in fly ash originated from selected plants; (ii) evaluate the impacts (air voids and expansion properties) of PAC-containing fly in air-entrained concrete; (iii) develop guidelines in controlling PAC in fly ash; and (iv) suggest appropriate tool(s)/technique to minimize the influence of PAC in fly ash-modified concrete.

Intended Implementation of Research

Workforce Development: This will be achieved directly by training graduate, undergraduate, and high school students interested in pursuing a career in STEM or Transportation Engineering career.

Education and Outreach: This task supports the federal initiative to build the next generation of transportation professionals to meet the demands of the rapidly changing 21st-century transportation system. The PI currently supports and mentors five graduate students and three undergraduate students from external grants. The proposed study will help the PI to recruit and train more graduate and undergraduate students within the transportation research.

Anticipated Impacts/Benefits of Implementation

Main deliverables from this research project are:

(1) A technical report containing findings of the project.

(2) An Implementation report containing major technology transfer initiatives. Such initiatives will contain at least two presentations to be made annual meetings organized by the ArDOT Technical Research Committee (TRC) and Tran-SET, a Create@State radio (KASU) podcast to be prepared and broadcasted, and a webinar organized by TranSET.

The findings of this study will help ArDOT and ready-mix concrete industries in the region to use knowledge learned on PAC injected fly ash modified concrete. It is expected to be significant cost savings for these agencies in selecting appropriate materials for producing sustainable concrete.

Web Links

- TranSET's website (https://transet.lsu.edu/research-in-progress/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/View/1642173)

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit Our Website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.