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

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

Highlight | Sept. 2020

Project No. 19CASU03

PI: Dr. Zahid Hossain (ASU)

Start Date: 08/15/2019

End Date: 02/15/2021

Class C Fly Ash (CFA) is commonly used as supplementary cementitious material (SCM) in producing concrete by ready-mix concrete contractors in Arkansas. However, CFA can be used as a partial replacement of Ordinary Portland Cement (OPC) if it meets certain ASTM requirements. It is believed that the presence of powder activated carbon (PAC) in CFA increases the demand of the air-entraining agent (AEA) to achieve specified air content, and this is a concern to transportation agencies such as the Arkansas Department of Transportation (ARDOT) and concrete producers in recent years. Thus, the main goal of this research is to assess the influence of PAC in fly ash on the properties of concrete. To achieve the goal of this study, a total of 14 mixes (12 laboratory and two plant mixes) were evaluated to determine the fresh concrete properties (e.g., air content, workability, and unit weight) as well as hard concrete properties (e.g., compressive, tensile and flexural strength, modulus of elasticity, and long-term durability). Besides the Pressure Meter method, a Super Air Meter (SAM) and a Miller 400A resistivity meter were used in this study to determine the air quality and electric resistance, respectively, of the prepared fresh concrete. Two CFAs containing the different percent of PAC (i.e., 0%, 0.25%, 0.50%, and 0.75% by the mass of CFA) were used to prepare the mixes where the dosage of AEA was selected based on the manufacture recommendation. Air content measurements of two selected hard concrete mixes were also made in the laboratory.

Background

Ready-mix concrete contractors routinely use CFA as supplementary cementitious material (SCM) in producing concrete. The CFA is used as a partial replacement of OPC. However, transportation agencies such as the ARDOT are concerned about some CFAs as they contain PAC, which may create adverse impacts on the target air voids and post-construction durability of air-entrained concrete. The PAC in fly ash increases the demand of the air-entraining agent (AEA) to achieve the desired air content. Therefore, the agencies and ready mix plant operators need a tool and/or technique so that necessary measures can be taken so that an appropriate amount of AEA can be used in the concrete mixes to obtain the desired air content. Also, special provisions can be included in the quality control/quality assurance guidelines for the ready-mix plants for using fly ash containing PAC in preparing concrete.

Project Summary

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) conduct a thorough literature review, (ii) evaluate the physical properties (e.g., specific gravity, moisture content, and absorption) of ingredients used in preparing concrete samples, (iii) evaluate the impacts (air voids and expansion properties) of PAC-containing fly in air-entrained concrete, (iv) evaluate strength properties and air content of hard concrete, (v) suggest a tool to measure the required amount of air-entraining agent in producing concrete with the desired air content and suggest appropriate tool(s)/technique to minimize the influence of PAC in fly ash-modified concrete. To accomplish the aforementioned objectives a set of tasks containing the evaluation of laboratory and plant mixes has been identified and executed in this study.

Status Update

A Super Air Meter (SAM), a modified version of a typical pressure meter (ASTM 231), was used to determine the air-void quality in the fresh concrete mixes, as shown in Figure 1. The SAM test results suggested that that the incorporation of CFAs with a certain percentage of PAC is desirable to satisfy the freeze-thaw requirement (ACI durability criteria).

Figure 1. SAM Tests of Fresh Concrete Mixes.

A Miller 400A analog resistivity meter was used to determine the electrical resistivity of the fresh concrete mixes in this study, as shown in Figure 2. The results showed that 0.75% PAC containing CFAs-modified concrete had the least resistivity value, thus, indicating the higher conductivity of the mixes. As a result, the corrosion rate of concrete produced with higher PAC percent in the CFAs will increase and reduce concrete durability.

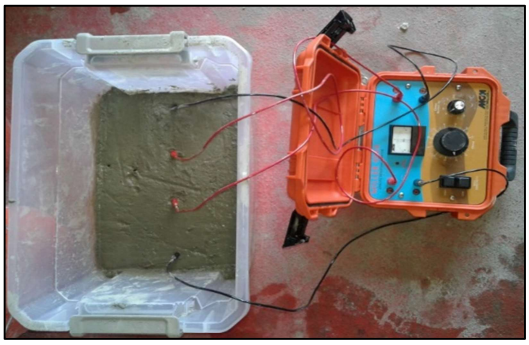

Figure 2. Electrical Resistivity Test Set-up.

Some of the major findings are:
(a) a higher amount of PAC (0.75%) in CFA reduced the workability (slump value) of concrete compared to the 0.5% PAC (typical) samples
(b) the air contents of the mixes were significantly affected by the incorporation of PAC in the CFA-modified concrete. The air content test results suggested that the CFA containing no PAC had higher air content, whereas a lower air content was observed in the case of higher PAC content.
(c) the Foaming index test can be followed to determine the dosage level of the air-entraining-agent (AEA). Based on the FIT results, it is evident that the required AEA dosages were increased with the addition of CFAs and PAC content as well to generate the permanent foam in the mixes. It is observed that the optimum AEA dosage obtained in the laboratory is always higher compared to the corresponding plant mixes produced as per the AEA manufacturer's recommendation.
(d) the SAM was found to be useful in determining the air-voids quality in the fresh concrete. The SAM test results suggested that that the incorporation of CFAs with a certain percentage of PAC is desirable to satisfy the freeze-thaw requirement (ACI durability criteria).

Impacts

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. The main benefits of this study are (a) increase the use of CFA as SCM in transportation construction projects, (b) enhance training opportunities for students in the region. 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 include disseminating findings at the annual TranSET conference and a Create@State radio KASU podcast.

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 our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.