

# **Development of Controlled Low Strength Materials and Concrete Using High Carbon Fly Ash and Concrete**

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## **ABSTRACT**

This project was proposed as the first of a two-phase project to test high-carbon fly ash as a component of Controlled Low Strength Materials (CLSM) and concrete. The aim of this first phase (first year) of this project was to determine the feasibility of incorporating high-carbon fly ash into CLSM and concrete to lower electrical resistance. Ideally, lowered electrical resistance of the materials will reduce the required length, or entirely replace, the grounding electrodes currently in use for protection of electrical equipment from lightning strikes. Two different types of materials were developed, CLSM and concrete. Three different types of CLSM mixtures were developed for this project. These mixtures consisted of:

- Standard CLSM material containing fly ash, cement, and water
- CLSM containing fly ash, clean concrete sand, cement, and water; and
- CLSM with clean concrete, sand, gravel, cement, and water.

The three different types of concrete mixtures were developed for this project. They were:

- High volume fly ash concrete, 43% fly ash by weight of cementitious materials;
- High volume fly ash concrete mixture with conductive steel fibers added; and
- High volume fly ash concrete containing heavyweight coarse aggregate.

Measurements for the CLSM mixtures show smaller electrical resistance than the concrete mixtures. This observation is true for both the saturated and dried specimens. The permeability measurements are also smaller for the CLSM mixtures than concrete mixtures. This indicates that increasing the fly ash content will lower the electrical resistance. It also suggests that CLSM mixtures have better electrical properties than the concrete mixtures. They are, therefore, better candidates for further grounding enhancement studies.

For the concrete mixtures, Mixture 50 with added steel fibers shows the smallest electrical resistance. However, compared with CLSM mixtures, its resistance value is still much higher. In order for the steel fiber to increase the conductivity, it is necessary to provide fiber to fiber continuity throughout the concrete so that a conductive fiber

network might be formed in the concrete. Mixture 50 did not have that. The results of the electrical tests suggest that the focus of the next step of this project should be on the specimens with high fly ash content.

The test results, though not conclusive, indicate certain trends that assist in the selection of materials required for the next phase of the project. The CLSM or concrete mixtures used in the next phase should maximize the high-carbon fly ash content. The conducting materials added to the CLSM or concrete mixtures should also be as fine as possible.