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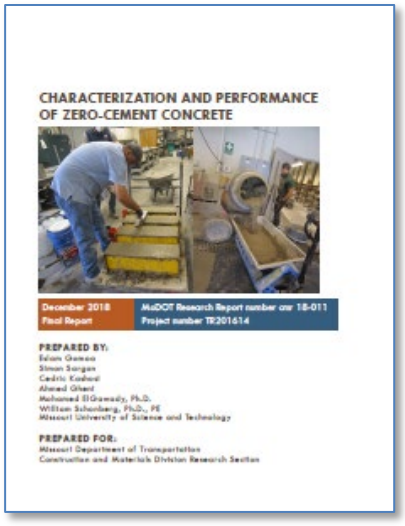
Research Summary

Characterization and Performance of Zero-Cement Concrete



This study investigated the feasibility of using locally available fly ashes (FAs) to synthesize zero-cement concrete (ZCC) for different structural and repair applications. Using ZCC made of 100% FA reduces global CO_2 emissions, saves energy, and decreases raw material consumption during the production process of ordinary Portland cement.

Class C FAs, sourced from Labadie, Jeffrey, Kansas City, Thomas Hill, and Sikeston power plants in the state of Missouri, were used to synthesize the ZCC. Two different alkali activators (Alk) were used in this study: sodium silicate (SS), Na2SiO3, and sodium hydroxide (SH), NaOH. Slag, crumb rubber, and air-entraining admixture (AEA) were used in a few mixtures as additives to improve the durability of the ZCC.

The mixing procedure, water/FA, Alk/FA, SS/SH, curing regime, fresh properties, mechanical properties, durability, repair applicability, and cost analysis of the ZCC were investigated in this study. Approximately 300 mortar and concrete mixtures were tested. A 5000 psi MoDOT conventional concrete (CC) mixture was prepared and tested for comparison purposes. Three curing regimes (oven, ambient, and moist) were applied to the ZCC.

This study revealed that ZCC can be used as a replacement for CC. ZCC showed good workability and adequate compressive strength for structural applications ranging from 3,660 psi to 7,465 psi based on the curing regime and source of FA. Some ZCC mixtures successfully passed 300 cycles of freeze and thaw per ASTM C666-15 procedures A and B.

Furthermore, the drying shrinkage values of the ZCC specimens at all ages were significantly lower than those of the CC specimens. ZCC also presents higher corrosion resistance compared to CC. ZCC mixtures have a low to moderate permeability and chloride ion penetrability, while the CC mixture showed a high permeability and chloride ion penetrability.

Finally, ZCC can be used as a repair material for existing concrete structures. The bond between ZCC as a repair material and CC as a host material was adequate and comparable to the bond between CC and CC.

The relationships between the compressive strength of ZCC and splitting tensile strength, flexural strength, and modulus of elasticity are similar to those used by current codes and standards such ACI 318-14. Finally, ZCC is cost

competitive; the cost of ZCC ranged from $59/yd^3 to $105/yd^3.

> *"Zero-cement concrete can be used as a replacement for conventional concrete."*

Setting time testing of zero-cement mortar

Project Information

PROJECT NAME: Zero-cement concrete

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PROJECT COST: $100,000

LEAD CONTRACTOR: Missouri University of Science & Technology

PRINCIPAL INVESTIGATOR: Dr. Mohamed ElGawady

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