Motivation
- The production of one ton of cement requires 1.7 ton of raw materials, 0.1 ton of coal and 100 kWh of electricity and produces one ton CO2.
- Cement production is responsible for 5-8% of man-made CO2 emissions.
- The world annually generates approximately 750 million tones of fly ash (FA) which is a by-product generated when burning coal in power plants.
- The state of Missouri generates approximately 2.7 million tons of coal combustion residuals annually, making Missouri the 16th largest CCR producer in the nation.
- Approximately 50% of this FA goes to landfills and ash ponds which may trigger environmental risks and safety hazard.
- Replacing cement in concrete production with FA addresses both issues.

This study develops zero-cement concrete (ZCC) where 100% of the cement is replaced with FA and alkali activator.

Materials
- Fly ash was used for producing ZCC.
- Five different types of fly ash were sourced from Labadie (C37), Jeffery (C29), Kansas City (C26), Thomas Hill (C24), and Sikeston (C21) power plants.
- The alkali activator used in this study consisted of sodium silicate and sodium hydroxide with Molarity of 10 M.

Research Objectives
The main overarching objective of this project is to develop a ZCC for structural applications using 100% class C fly ash. In particular, this project investigates:
- The optimum mixing procedure and mix design for ZCC.
- The mechanical properties of ZCC under different curing regimes.
- The durability, repair applicability, and cost of ZCC.

Experimental Work
- More than 200 trial ZCC mixtures are prepared to optimize design mixtures.
- Eight different mixing procedure were studied to obtain the higher workability as well as the optimum compressive strength.
- The effect of the chemical and physical properties of the FAs on the strength of ZCC were studied.
- The mechanical properties including compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity development at different ages were studied.
- Three curing regimes were studied including ambient, moist, and oven curing.
- The Durability of ZCC including freeze-thaw resistance and reinforcement corrosion protection tests were studied.
- The applicability of using ZCC as a repair material was studied by two tests; slant shear and pull-off tests.
- The cost analysis of the ZCC was studied.

RESULTS
Slump and compressive strength
- Slump values of the ZCC and CC mixtures were studied.
- The mechanical properties results showed a good matching with the design codes equations.

Splitting tensile and flexural strength
- Tensile strength of ZCC and CC mixtures were studied.
- Flexural strength of ZCC and CC mixtures were studied.

Durability
- Freeze and thaw
- The ZCC showed comparable slump and compressive strength similar to that of CC.
- oven, ambient, and moist cured zero cement concrete reached a compressive strength of 6100 psi, 5300 psi, and 7500 psi after 1, 7, 28 days of curing, respectively.
- The mechanical properties results showed a good matching with the design codes equations.
- ZCC displayed resistance for freeze and thaw, and reinforcement corrosion.
- ZCC displayed a potential use as a repair material for the CC structures.
- The cost of the ZCC was comparable to that of CC.