Clayey Soils and Waste Brick Powder for Partial Cement Replacement

Anuja Oke[a], Mumbi Kimani[b], Esther Obonyo[b,c], Mehrzad Zahabi[c], Aly Said[c]

[a]The University of Arizona, [b]Engineering Design, [c]Architectural Engineering

The Pennsylvania State University, College of Engineering

PennState | DRAWDOWN

Introduction

cement production accounts for 7% of industrial carbon dioxide emissions[1]

Supplementary cementitious materials

Clayey soils Morph into metakaolin when heated

Brick Waste Pozzolanic when ground into powder[2]

Methodology

Soil Identification

From literature review, Opequon soils were found to have a clayey subsoil[3].

Mortar Cube Preparation and Testing


Brick was placed under a compression machine (1) and broken apart into pieces (2).


The pieces were ground into a fine powder (4) and sieved through a 75-micron mesh using a sieve shaker (3).


Brick powder and cement was mixed (5), then added to a mixer with water and aggregate (6).


The mortar mix was placed in molds (7), covered for 24 hours (8), then demolded and cured in a water bath.

- Three separate batches with binder:aggregate:water ratio of 1:2.75:0.48[4] by mass
- 'Binder' portion of the mix was adjusted by replacing portions of cement with waste brick powder (Figure 4)

Figure 1. Compressive Testing

Characterization at the Microstructural Level

Brick powder was characterized using X-Ray Diffraction to determine the mineral composition and identify phases present in the sample.

Results

Soil Analysis

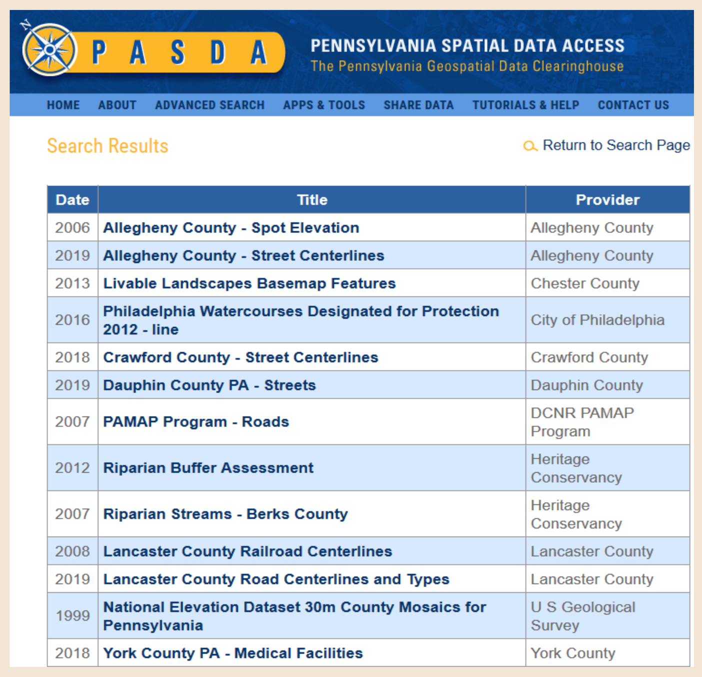

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Figure 2. using soil data obtained from Pennsylvania Spatial Data Access[5]

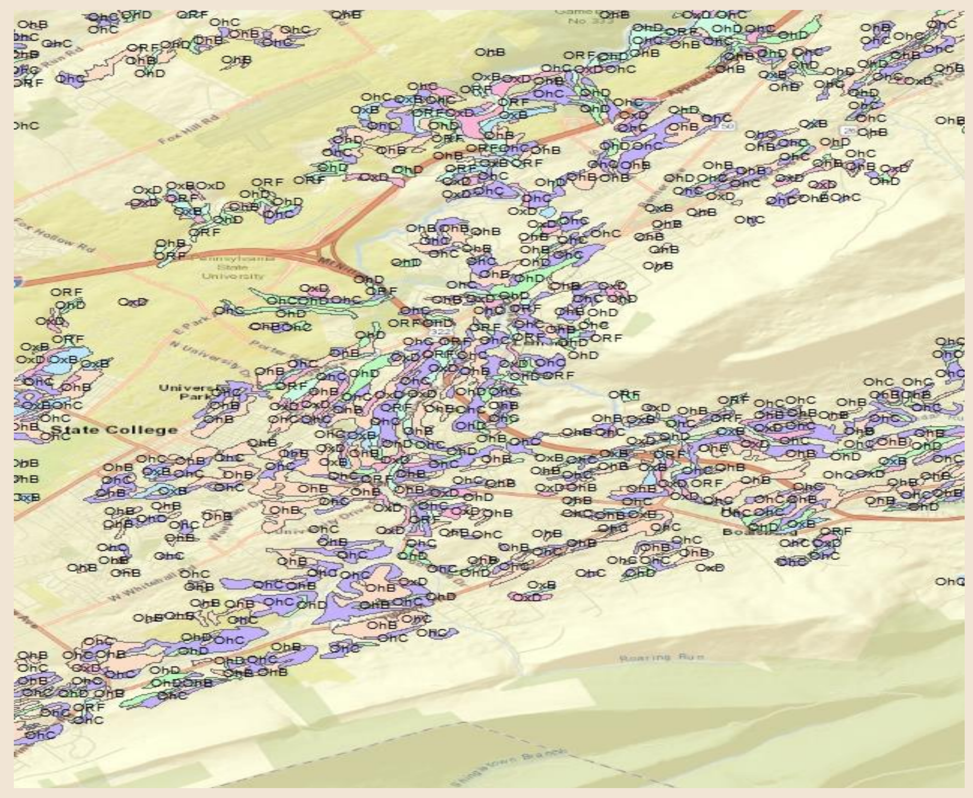

Figure 3. GIS software was used to identify Opequon soils in State College, Pennsylvania[5]

Compressive Testing

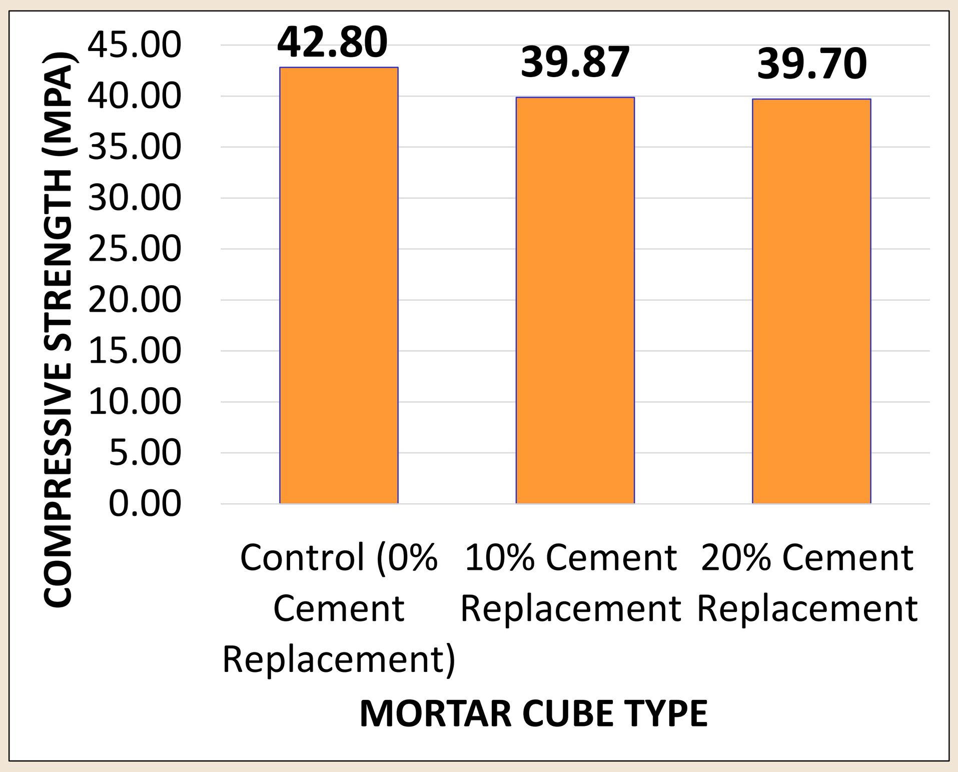

Figure 4. Compressive strength after 7 days of curing

X-Ray Diffraction

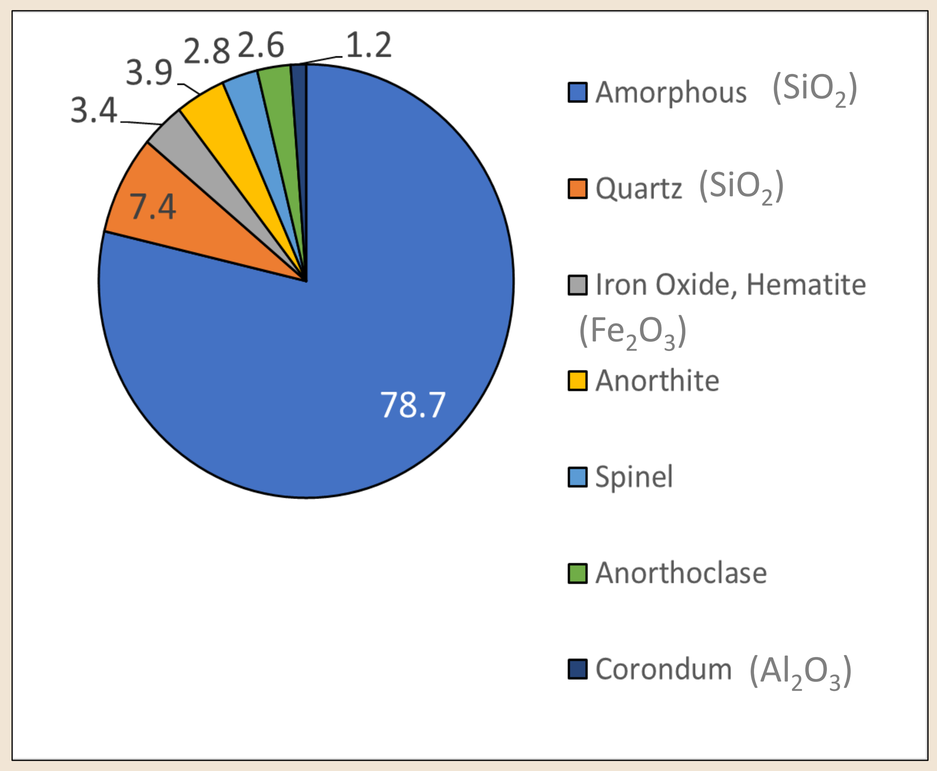

Figure 5. Phase and mineral weight percentages relative to total sample

Discussion

Findings

- Availability of clayey soil in State College, Pennsylvania was confirmed
- Compressive strength decreased by 7% with the partial replacement of
- cement with waste brick powder
- XRD analysis of waste brick powder revealed silica, alumina, iron oxide, and high amorphous content, suggesting it is a pozzolan[2]

Future Work

- Compressive strength testing at curing age of 90 days
- Conduct other tests for comparison to ASTM standards for pozzolans
- Measure extent of pozzolanic reaction

Acknowledgments

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References

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[2]Olofinnade, O. M., et al. "Sustainability of Waste Glass Powder and Clay Brick Powder as Cement Substitute in Green Concrete." *Handbook of Environmental Materials Management*, 2018, pp. 1–22.

[3]Zhu, Q., et al. "Functional Soil Mapping for Site-Specific Soil Moisture and Crop Yield Management."*Geoderma*, vol. 200–201, June 2013, pp. 45–54.

[4]ASTM C109/C109M-16a (2016). Standard Test Method of Hydraulic Cement Mortars (Using 2in or [50-mm] Cube Specimens). ASTM International, West Conshohocken, PA.

[5]"Centre County Soils." *Pennsylvania Spatial Data Access*.2014.