Analyzing the Effect of Ground Glass Pozzolan as a Supplementary Low-Carbon Cementitious Material in Concrete

[1]Bismark Yeboah, [2]Anna Casavant, Advisors: [2]Dryver Huston, [1]Mandar Dewoolkar, [1]Civil and Environmental Engineering, [2] Mechanical Engineering, University Of Vermont

Project Statement

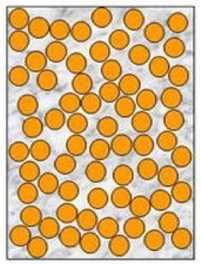
Concrete is the most widely used construction material in the world. To achieve high-performance concrete in terms of strength and durability, a high binder content is often used, which mostly consists of cement. However, about 5-7% of the world's total CO2 emissions are considered to be associated with cement production. Also, high binder content results in higher costs, cracking, and shrinkage damage. Reducing cement content in concrete, therefore, has sustainability benefits.

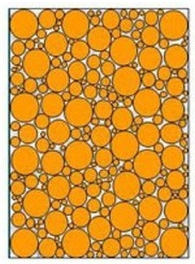
Objectives

This research seeks to develop concrete mix designs that meet modern high-performance durability standards while supplementing cement with ground glass pozzolan, a more environmentally-friendly concrete material.

The research will also explore mix designs with locally sourced materials whiles investigating the effect of packing density in optimizing binder and aggregate compositions.

https://pozzotive.com/product-benefits/





https://myrenovationspecialist.com/concrete-failure/

Fig 1: Ground glass pozzolan as supplementary low-carbon cementitious materials (left), poorly packed aggregates (middle), and well-packed aggregate with maximum packing density (right)

Some Preliminary Results

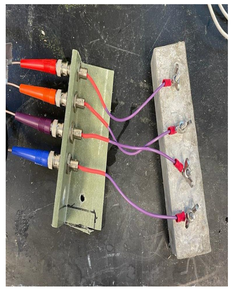
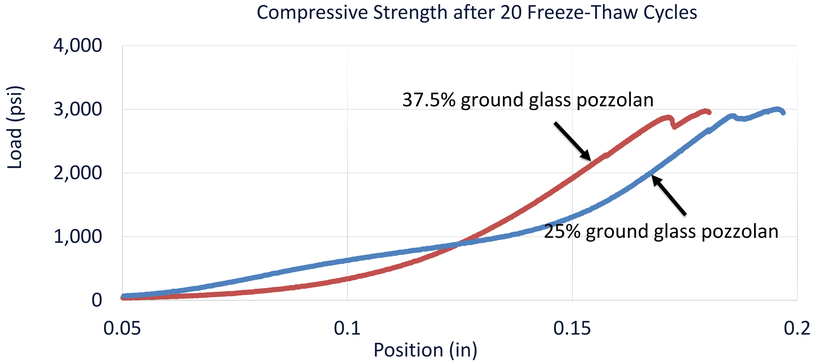


Fig 2 Compressive strength tests (left), electrical resistivity and chloride penetration tests (middle), and concrete shrinkage tests (right).



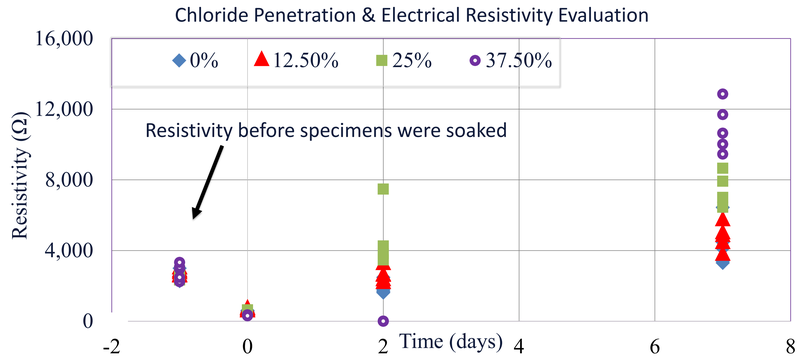


Figure 3. Results from compressive strength tests of specimens containing 12.5% and 25% ground glass pozzolan after 20 freeze-thaw cycles (up), Electrical resistance measure of chloride penetration for specimens containing 0%, 12.5%. 25% and 37.5% ground glass pozzolan (down).

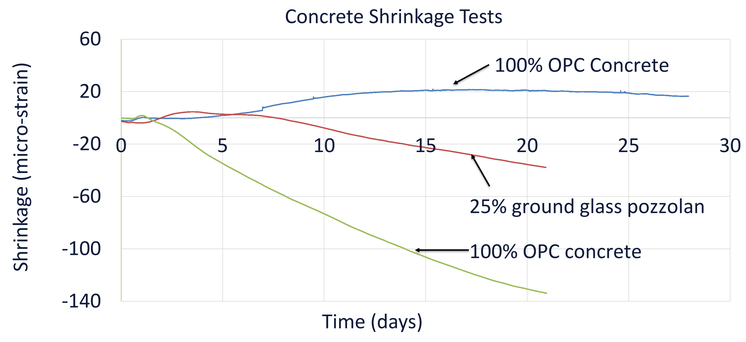


Fig 4. Results from concrete shrinkage test of 3 concrete specimens, two containing 100% ordinary Portland cement (OPC) and one containing 25% ground glass pozzolan.

Upcoming work

- Optimization of binder and aggregate composition by packing density.
- Development of concrete mix design by partially replacing cement with ground glass pozzolan and other supplementary low-carbon cementitious materials such as nano silica and Portland limestone cement.
- Determination of maximum packing density to reduce the void spaces of the aggregates hence reducing the binder paste required to fill the spaces.
- Explore mix designs with locally sourced materials, which has the benefit of reducing carbon emissions from aggregate transportation to enhance sustainability.
- Testing techniques to be employed: freeze-thaw, compressive strength, shrinkage, electrical resistivity, and chloride penetration.

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