Shrinking Chitosan Fibers to Improve Long Term Concrete Durability

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Introduction

For centuries, concrete has been the primary material used in construction. The strength and durability of concrete decrease over time. Adding fibers to concrete often prevents the spread of cracks while increasing tensile strength. Concrete with increased durability has reduced environmental impact. Previous research used steel fibers and polymer fibers to reinforce concrete. The fibers helped bridge cracks and prevented cracks from expanding. Fiber-reinforced concrete shows increased strength after the crack initiation and increased toughness, tensile strength, and compressive strength, a long-term durability step forward.

Results to Date

We experimented with adding chitosan fibers to concrete.

"Shells from peeled shrimp while preparing dinner", by Merrimon, licensed under CC BY-NC/ Cropped from original

"Technical Grade Chitosan Powder", by indiamart.com, licensed under CC BY/Cropped from original

Figure 1. Seashell's primary material to produce chitosan powder (left). Chitosan powder is used to produce chitosan fiber (right)

Freeze-thaw Testing Results

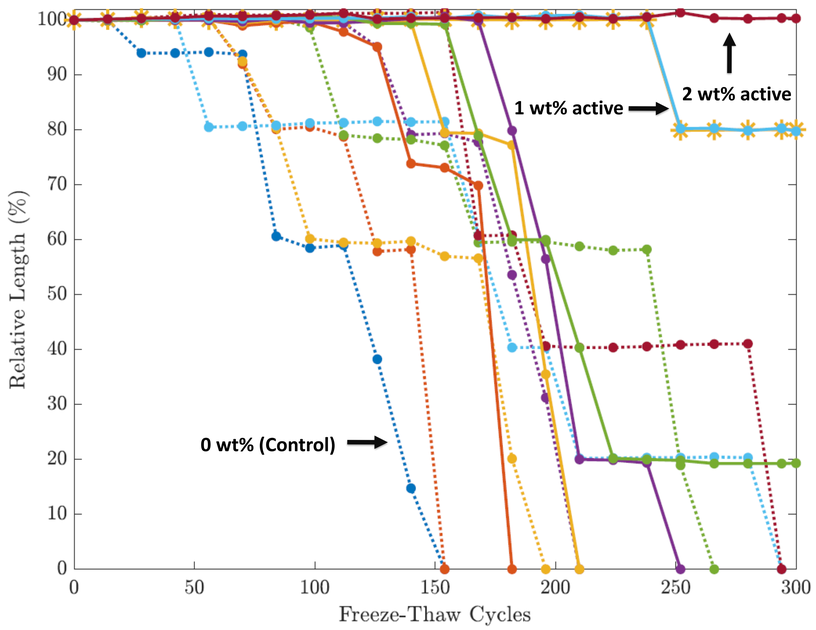

Figure 2. The relative mass of concrete for the various chitosan contents as a function of freeze-thaw cycles. 0 wt% is the control mix with no added fibers. All other mixes have added chitosan with two different types of chitosan, active and passive fibers. Passive fibers were created by preshrinking active chitosan fibers in an alkaline solution.

The chitosan reinforced concrete showed increased durability:

- The 1 wt% chitosan concrete had a 540.5% greater durability factor than the 0 wt% control group (No added fibers).
- After 300 freeze-thaw cycles, the 2 wt% chitosan fiber concrete was the only group with all its five specimens intact.
- In terms of length, mass, and relative dynamic modulus, the 0 wt% control group failed faster than any other chitosan group.

Planned Work

Four mixes will be tested, including a control mix without fibers, chitosan fibers of the same size, and smaller fibers with a higher aspect ratio. The mixes will study the effects of age and size/aspect ratio on the concrete durability. All the mixes will use active chitosan fibers, the difference between the active and passive fibers is that passive fibers are preshrinking in an alkaline solution. In the previous study, active fibers showed better results in all the tests. Based on that, only the active chitosan fiber will be used.

Figure 3. Newly prepared chitosan fiber sheet (left), chitosan fiber after being cut using a paper cutter (right)

Objectives

- Understanding the effects of age and size of chitosan fiber on concrete.
- Decreasing crack width in the hardened concrete.
- Studying the internal adhesion between the natural chitosan fiber and the concrete matrix.
- Increasing the long-term durability of concrete.

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