High Strength, Low Carbon Recycled Concrete

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Abstract

- Developing fully recycled, low-carbon concrete provides a path toward sustainable construction and contributes to lowering the annual CO_2 emissions produced globally by traditional concrete production.
- This research investigates the integration of concrete waste material into wollastonite-based carbonate concrete formulations.

Background

Problem: Traditional concrete production contributes to approximately 8% of global CO_2 emissions.

Goal: Develop fully recycled, low-carbon concrete using waste concrete and wollastonite, cured via carbonation at low temperature.

Significance: Demonstrates the use of circular construction and CO_2 storage utilization. These cementitious materials were formed and carbonated without exceeding 125°C.

Methods

Materials:
- Wollastonite ($CaSiO_3$): Binder.
- Sand and 3/8” granite aggregate: filler
- Crushed concrete rubble; Sieved into three particle size fractions
  - Coarse: >1.18mm - <5.6mm.
  - Medium: >300µm - <1.18mm.
  - Fine: <300µm.
- Different formulations were mixed and casted into 3” × 6” cylinders

Figure 1: *Cast Cylinders of Wollastonite and concrete rubble.*

CO_2 Curing Process: Carbonated at 90°C and <15 psi in 48- or 72-hour durations.

Figure 2: *Cylinders in carbonation chamber.*

Mechanical Testing:

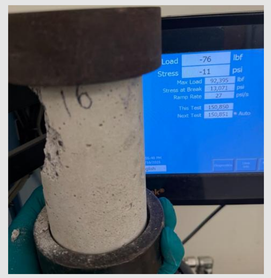

Figure 3 and 4: *Compression tested cylinders.*

Results

- Formulations containing
  - I. wollastonite, 3/8” aggregate, sand and concrete rubble *(Set #1, #2, #3)*
  - II. wollastonite and crushed concrete rubble only *(Set #4)*

were tested under various conditions

Table 1: *Processing conditions of different formulations*

Sample Set	Demolded Time/hr	Drying Time, Temp	Carbonation duration, Temp
#1	95	3hr, 125 ºC	48hr, 90 ºC
#2	95	99hr, RT	72hr, 90 ºC
#3	72	20.5hr, 90 ºC	48hr, 90 ºC
#4	24	4hr, 90 ºC	72hr, 90 ºC

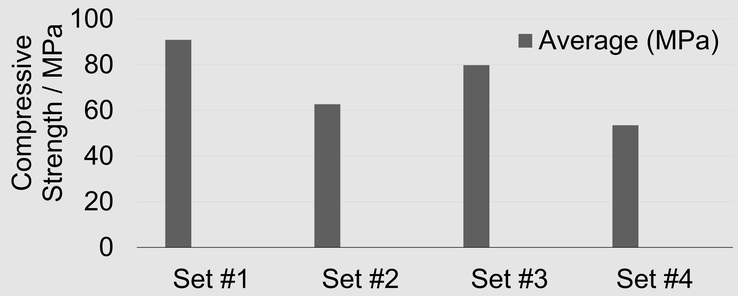

Figure 5: *Compressive strength results of carbonated cylinder sets.*

Future Direction

- Optimize mix ratios for various application types and maximize recyclability.
- Decrease wollastonite-based binder while introducing recycled cement hydrate.
- Explore modifications to CO_2 carbonation procedure.