

Creating Sustainable Concrete Through Carbon Sequestration

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Q1: Engineering Problem and Project Objectives

Three current methods of CO₂ sequestration in concrete:

Passive Carbonation

- ✓ Stable, long-term CO₂ storage
- ✗ Long exposure periods

Carbonation Curing

- ✓ Rapid CO₂ uptake
- ✓ Increased strength
- ✗ Inconsistent

Mineral Carbonation

- ✓ Stable carbonates
- ✓ Sustainable additives
- ✗ Strength tradeoffs

Approach: Combination of Mineral Carbonation and Carbonation Curing
 Engineering Goal: Create and optimize a **structurally sound** concrete mix from **recycled materials** that **quickly and consistently sequesters CO₂** when carbonation-cured

Q2: Project Design

Factors	Level 1	Level 2	Level 3
SCM	Fly ash	Slag	Hydrated Lime
Aggregates	Recycled	Natural	Steel Slag
Additives	None	Biochar	Accelerator
Water-Binder	0.35	0.4	0.45

Table 1. L9 Taguchi Array showing factors and levels

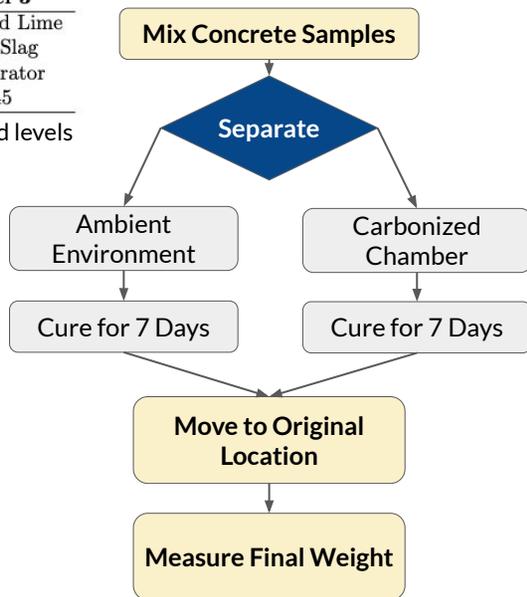
Structural Test:

Compression test until failure

- Peak load recorded

Carbonation Testing:

Three trials; Trials 1 and 2 tested original concrete mixes, Trial 3 tested optimized mix



Q3: Data Analysis and Results

CO₂ Sequestration :

Optimal Mix: performed the best, sequestering 6.60% of original mass; most consistent, shown in 95% CIs and SDs

Mix	Mean CO %	SD	95% CI (lower, upper)	CI width
1	5.215	0.869	(3.833, 6.597)	2.764
2	3.740	0.732	(2.575, 4.905)	2.330
3	4.123	0.473	(3.371, 4.875)	1.504
4	2.835	0.868	(1.454, 4.216)	2.762
5	4.910	0.376	(4.312, 5.508)	1.196
6	3.305	1.153	(1.470, 5.140)	3.670
7	4.390	0.566	(3.489, 5.291)	1.802
8	3.523	0.485	(2.751, 4.295)	1.544
Optimal	6.600	0.0258	(6.559, 6.641)	0.082

Table 2: 95% Confidence Interval (CI) for CO₂ sequestration of each mix

Compression:

- 7 out of 8 original mixes improved strength
- 3 met standards for commercial usage (4000 psi)

Experimental vs Control Compression

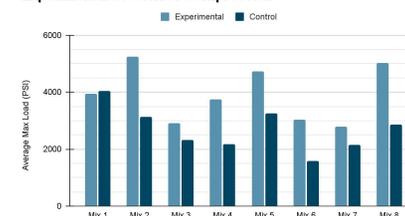


Figure 5. Experimental vs Control Compression Testing

Q4: Interpretations and Conclusions

✓ **Recycled materials** were incorporated as SCMs and aggregates in the concrete matrix, including steel slag and recycled concrete

✓ **Rapid CO₂ sequestration** achieved through the optimal mix which sequestered 6.60% of its original mass in a 7 day period

✓ **Consistent CO₂ sequestration** was demonstrated in the optimized mix. Additionally, each sample of each mix retained the sequestered CO₂ between the end of carbonation and the final measurement.

✓ **Structural Strength** met industry standards for 3 out of 8 mixes
 ✓ **Applications: scalable process** viable for controlled-production settings, especially applicable for **modular construction**



Photo taken by Shivani Wadawadigi