

### Problem Definition

- Concrete is one of the most widely used construction materials, and its production contributes to about 8% of global emissions annually (Logan & Gregory, Climate Portal).
- Improving sustainability of concrete:
  - Supplementary Cementitious Materials (SCMs) are materials that can be substituted into cement to improve the properties of concrete
  - Biochar algae has a fine particle size and high silica content, making it a potentially viable SCM (Feasibility of Algal Biochar, a Byproduct of Biofuel Production, as a Supplementary Cementitious Material)
  - Biochar algae is renewable and has the potential to sequester CO<sub>2</sub> from atmosphere
  - Using Green Mechanics-harvested algae from Algal Turf Scrubber as a SCM, wasted algae can be repurposed
- Further research is needed to evaluate the changes in compressive strength and CO<sub>2</sub> sequestration with increasing amounts of biochar in cement mixture
- GOAL:** Determine the optimal % biochar for the best compressive strength and carbon sequestration capacity.

### Design Calculations & Analysis

- We used 3 replicates each of Biochar-Cement ratios 0%, 10%, 20%, 25%, and 30%.
- Based calculations of concrete design on moisture content and compressive strength found in study "Feasibility of Algal Biochar, a Byproduct of Biofuel Production, as a Supplemental Cementitious Material"

Biochar-Cement Ratio	Mass cement (kg)	Mass Biochar (kg)
0.3	0.28	0.12
0.25	0.30	0.10
0.2	0.32	0.08
0.1	0.36	0.04
0	0.40	0.00
Fine Aggregate Mass (kg)	Coarse Aggregate Mass (kg)	Mass Water (kg)
2.31	2.24	0.22

Test	Equation
UPV	$Pulse\ Velocity = \frac{Length\ of\ Specimen}{Area}$
Compressive	$Pressure = \frac{Max.\ Force}{Area}$
Carbon Incubation	$Expected\ Uptake = [\% Post\ Carbonation\ CO_2] \frac{Weight\ Before\ Carbonation}{Weight\ After\ Carbonation} - [\% Pre\ Carbonation\ CO_2]$ $Theoretical\ Uptake = 0.785(CaO - 0.56CaCO_3 - 0.75O_2) + 1.091MgO$ $Efficiency = \frac{Expected\ Uptake}{Theoretical\ Uptake}$

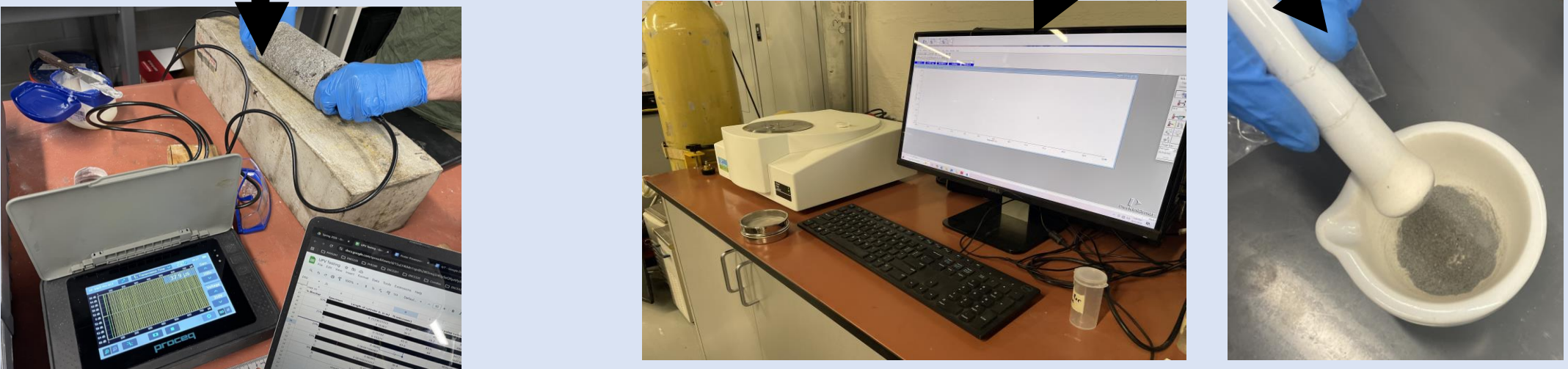
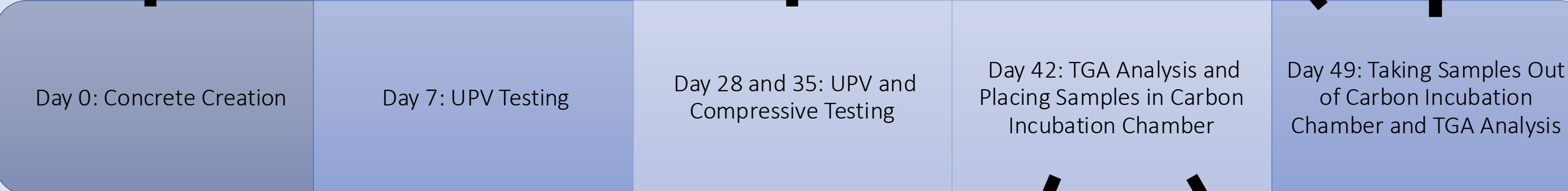
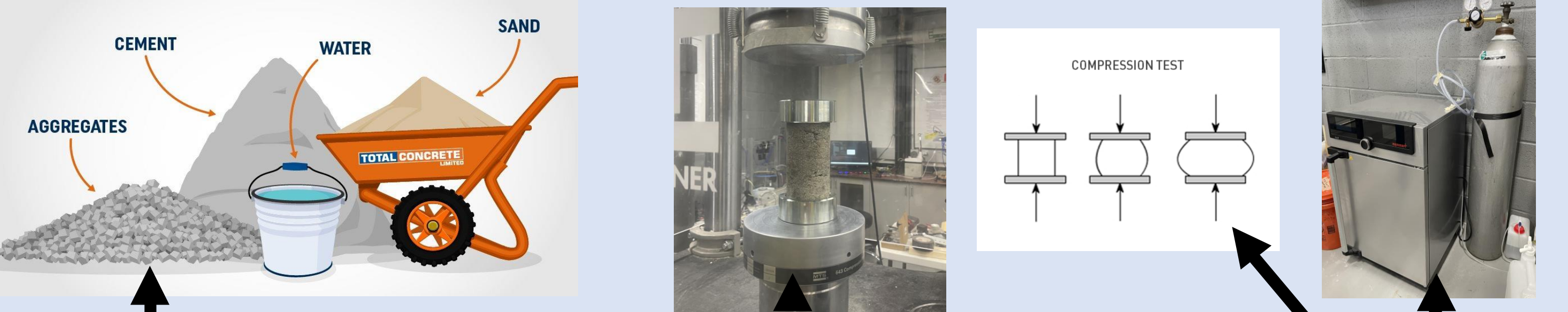
Concrete Design Calculations

Equations Used for Each Test

UPV Testing: Higher pulse velocity indicates more voids and a weaker concrete.  
 Compressive Testing: Higher pressure at failure indicates a stronger concrete.  
 TGA: Change in carbon composition in samples before and after carbon chamber testing indicates ability to sequester carbon. Higher change in carbon composition indicates more carbon sequestered.  
 Carbon Incubation: Higher carbon value indicates more ability to sequester.

### Procedure

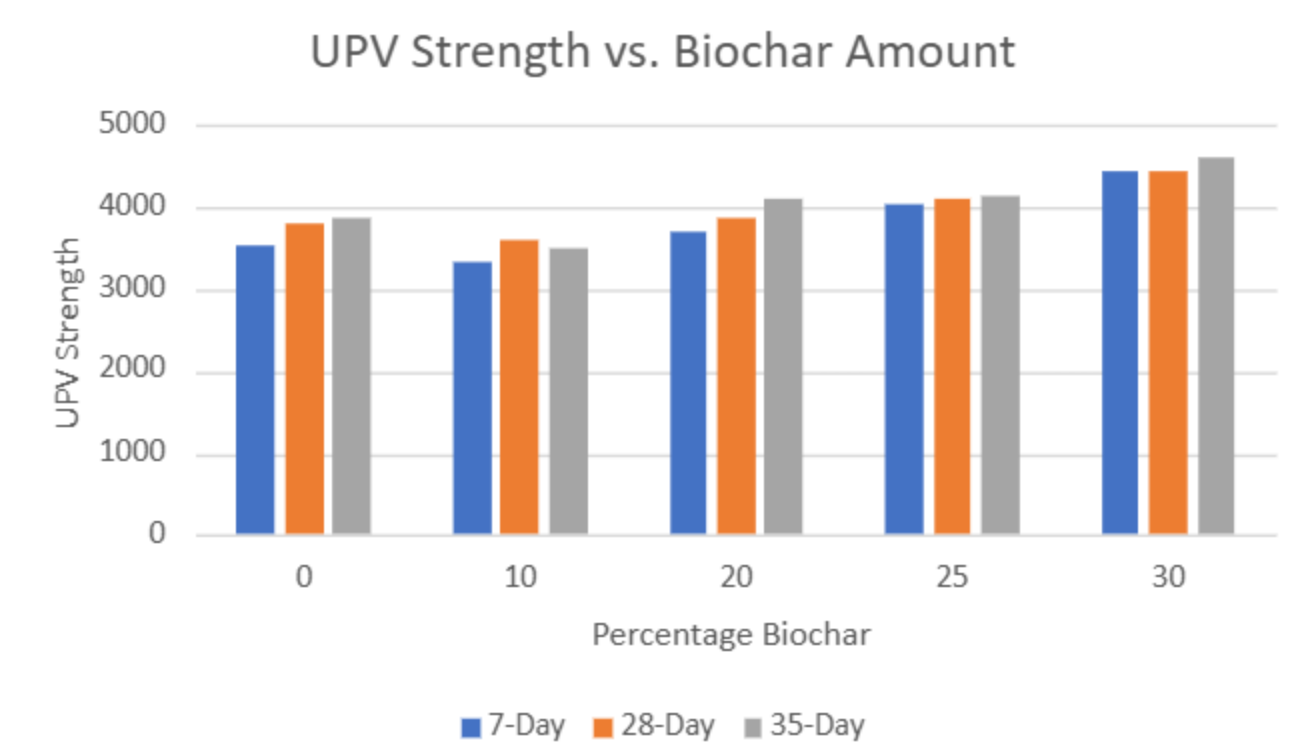
Test	Purpose	Standard
Concrete Creation	Mix components and let cure	ASTM C192
UPV	Determine amount of voids	ASTM U597
Compressive	Determine load/pressure required for failure/ maximum strength	ASTM C39
Carbon Incubation	Determine amount of carbon sequestered	ASTM
Thermo-Gravimetric Analysis	Determine percent composition of concrete	ISO 1920-12



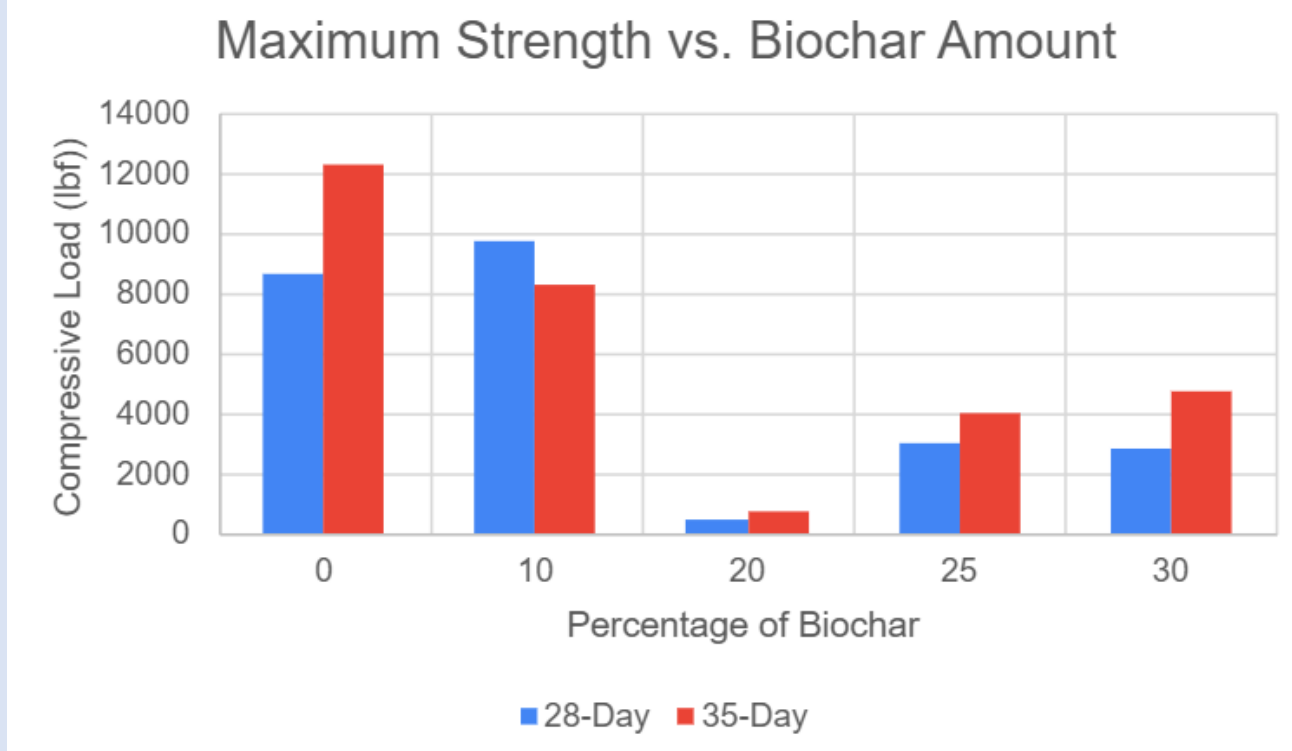
### Results



30% Biochar Compression Testing Failure



UPV Testing Results



Compressive Strength Testing Results

Our compressive and UPV testing results showed opposite effects. While UPV showed a trend where increasing biochar concentration improved the quality of concrete, compressive testing showed overall that a higher concentration of biochar yielded lower compressive strength.

### Conclusions

- UPV strength increases as more biochar is added and the time to cure increases
- Compressive strength is greater for samples with smaller biochar content (0% and 10%) and similar for 25% and 30% samples
- Overall, algal biochar is not a viable cementitious material because of its negative impacts to compressive strength of concrete. Algal biochar should therefore not be used in concrete production due to safety concerns.

### Recognition

- Larry Davis
- Dr. Jianqiang Wei
- Dr. Yuan Feng
- Muhammad Mustafa
- Himmel's Landscape and Garden Center, LLC
- Dr. Gretchen Bella
- Dr. Juzhong Tan
- Dr. Niemeier