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MINES

The Feasibility of Biochar as a Cement Replacement to Reduce Concrete's Carbon Footprint

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Concrete Basics

Concrete vs. Cement



CONCRETE

Concrete is the final hardened material that contains cement, water, and aggregate.



CEMENT

Cement is the reactive powder that gets mixed with water and binds everything together.



Concrete Basics

Concrete vs. Cement vs. Mortar



CONCRETE

Cement

Water

Fine Aggregate (Sand)

Coarse Aggregate (Gravel)



MORTAR

Cement

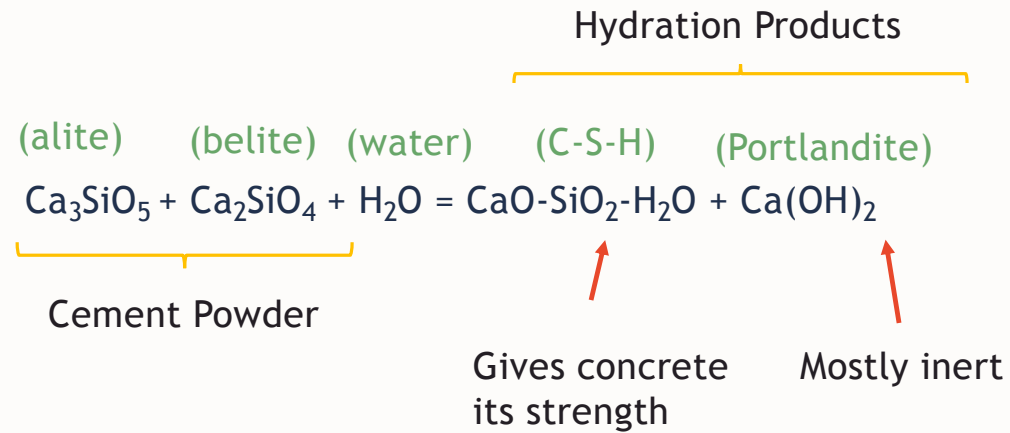
Water

Fine Aggregate (Sand)



Concrete Basics

Cement Chemistry

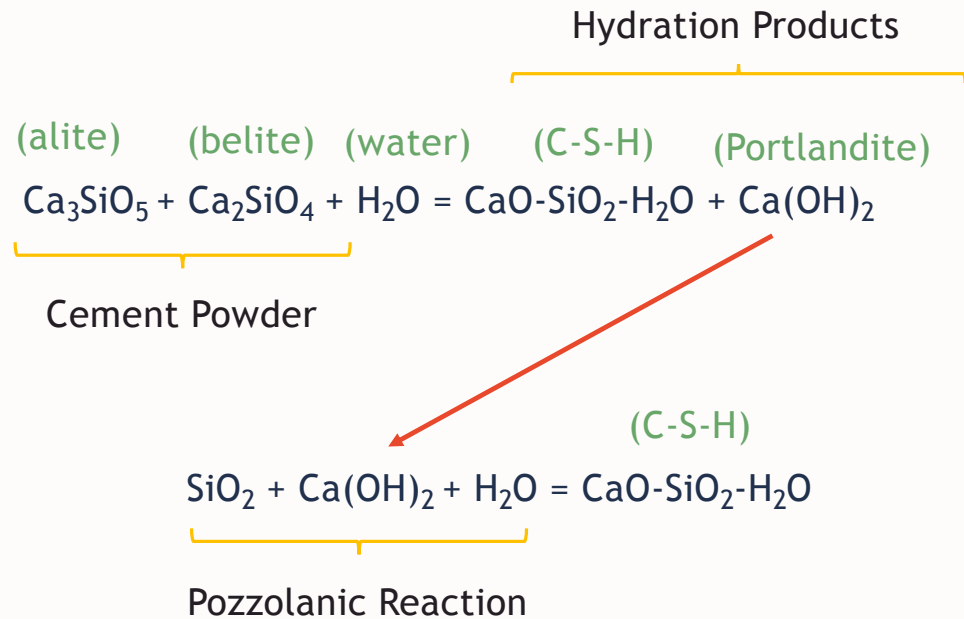


***H2O is used for dissolution AND consumption in this hydration reaction**



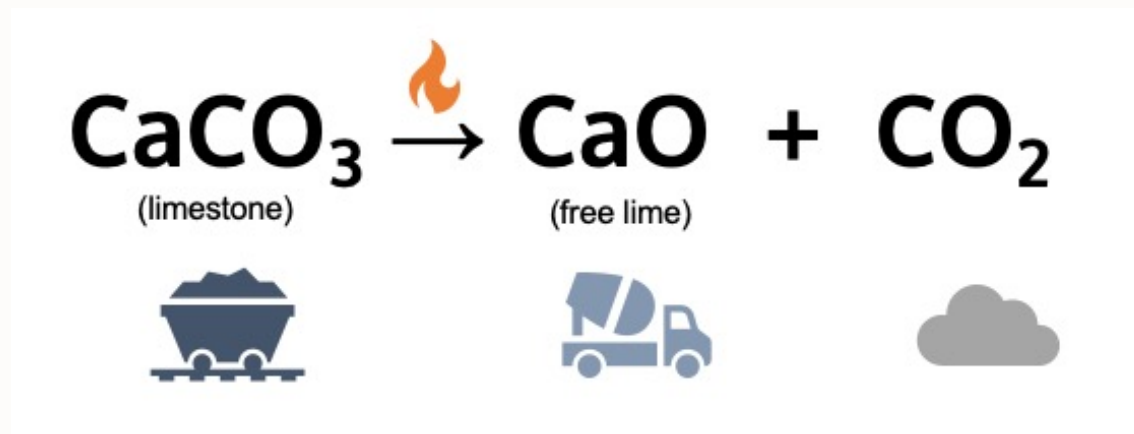
Concrete Basics

Pozzolanic reaction



Concrete Basics

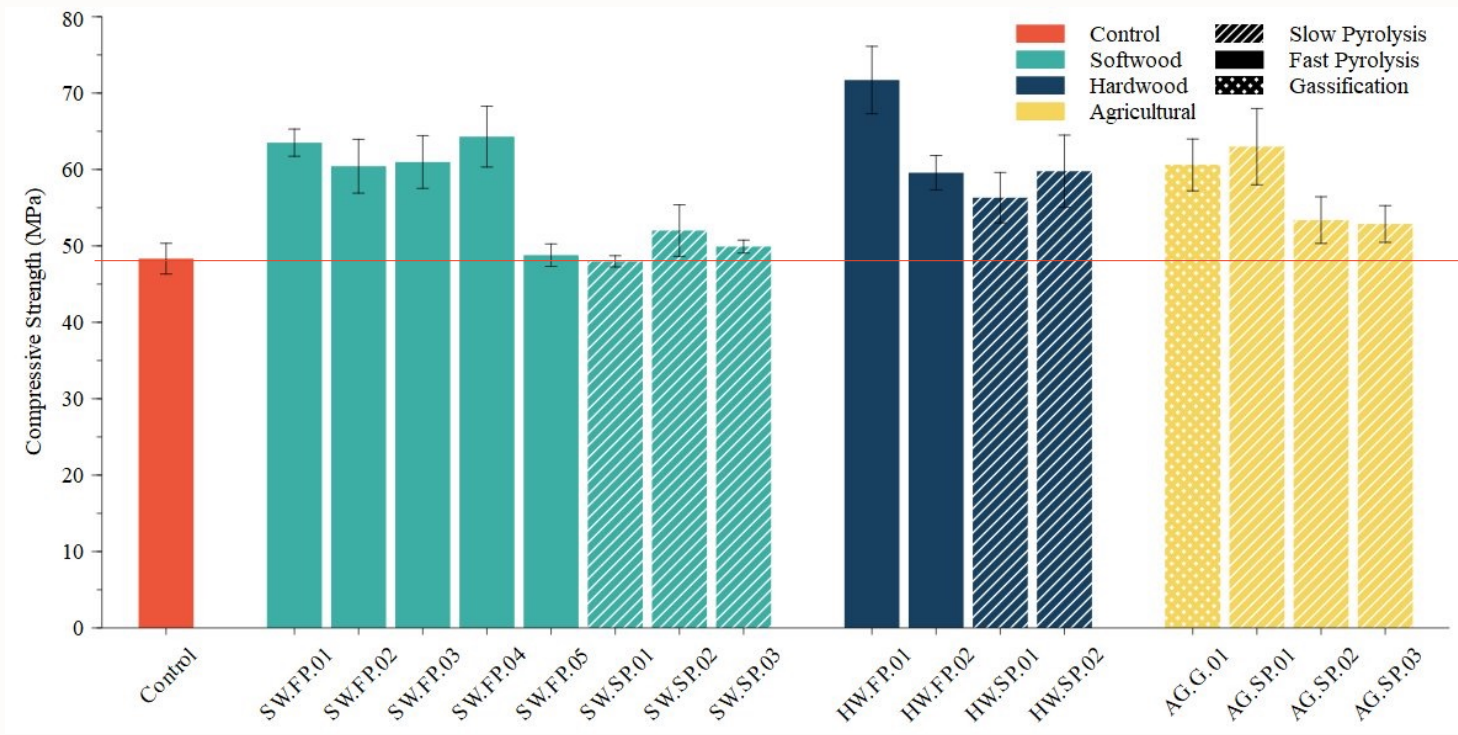
What's the problem with cement?



FOR EVERY 1 KG OF CEMENT PRODUCED, 0.93 KG OF CO₂ IS EMITTED

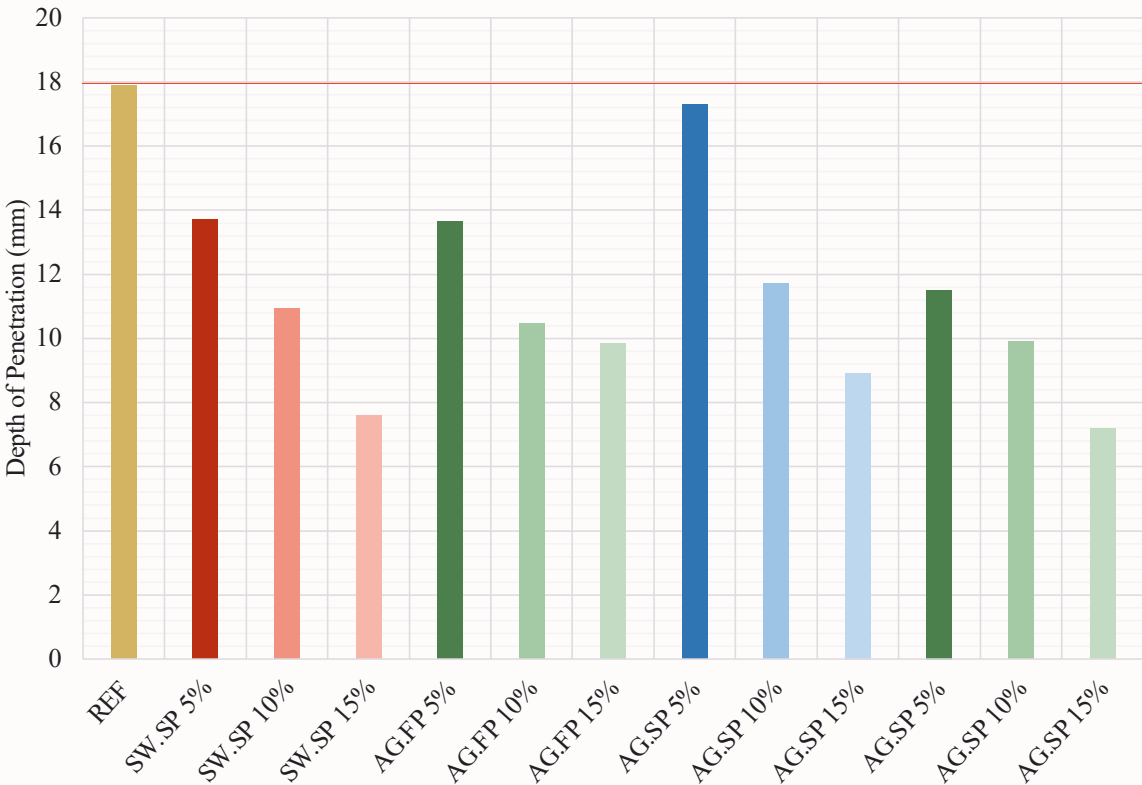
Biochar cementitious composites

Improved Strength



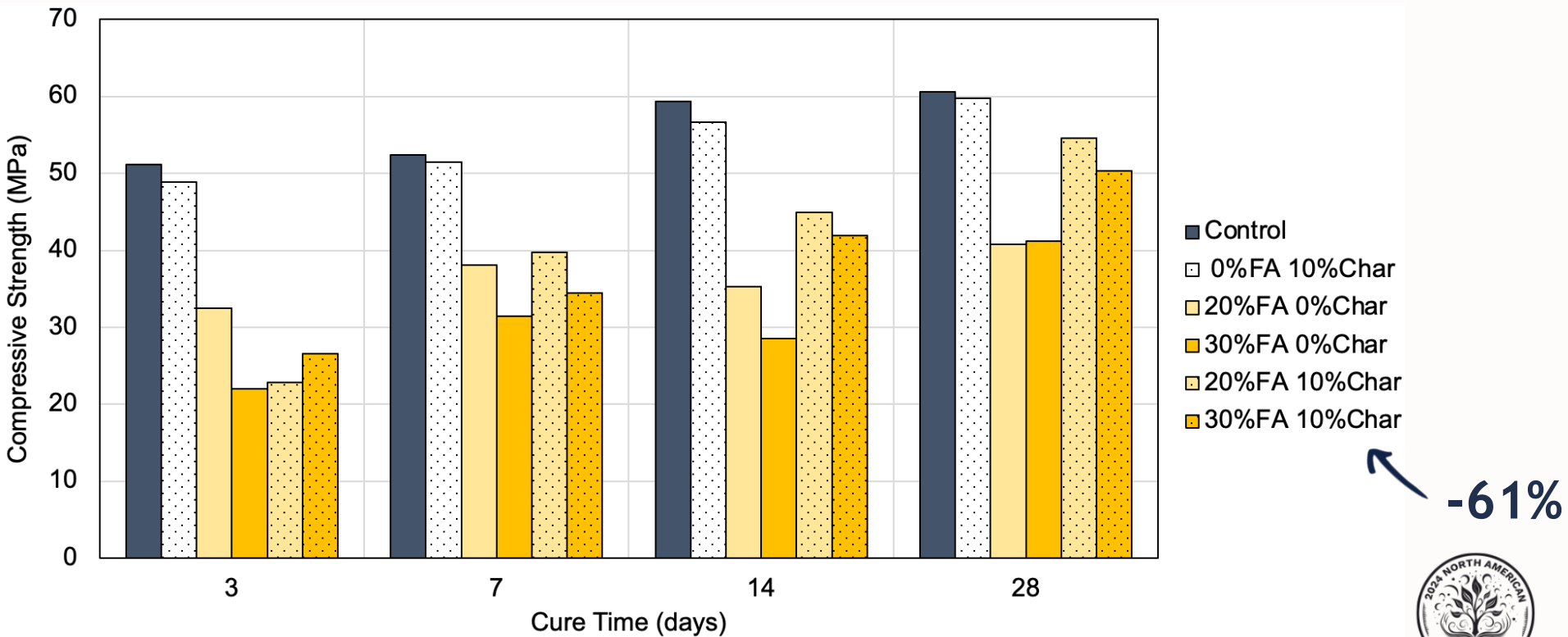
Biochar cementitious composites

Decreased Permeability



Biochar cementitious composites

Compatibility with pozzolanic materials (fly ash)



Biochar cementitious composites

What kind of biochar works?

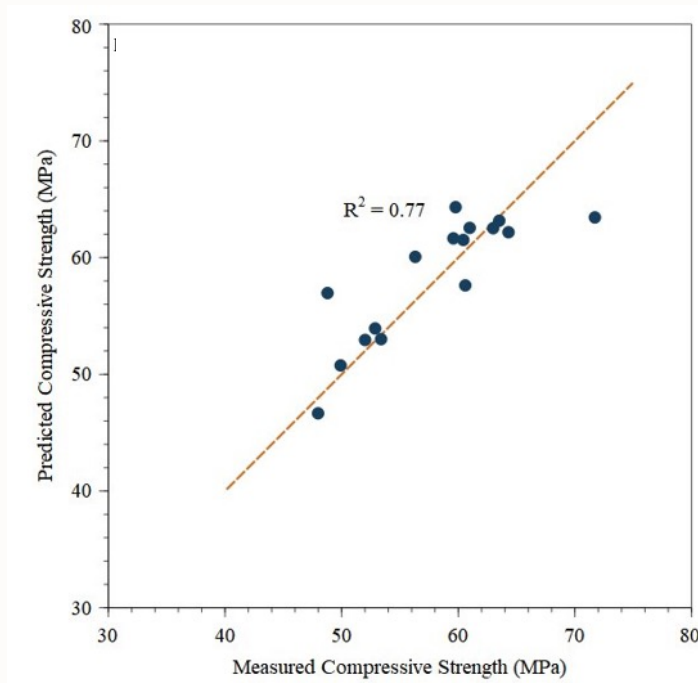
Biochar Sample Name	Feedstock Category	Pyrolysis Type	Temperature (°C)
SW.FP.01	Softwood	Fast	760
SW.FP.02	Softwood	Fast	500
SW.FP.03	Softwood	Fast	500
SW.FP.04	Softwood	Fast	500
SW.FP.05	Softwood	Fast	500
SW.SP.01	Softwood	Slow	700
SW.SP.02	Softwood	Slow	700
SW.SP.03	Softwood	Slow	700
HW.FP.01	Hardwood	Fast	500
HW.FP.02	Hardwood	Fast	500
HW.SP.01	Hardwood	Slow	400
HW.SP.02	Hardwood	Slow	500
AG.G.01	Agricultural	Gasification	1100
AG.SP.01	Agricultural	Slow	450
AG.SP.02	Agricultural	Slow	800
AG.SP.03	Agricultural	Slow	800



Biochar cementitious composites

What kind of biochar works?

$$\text{Compressive Strength} = 65.03 - 71.2 * (\text{ambient saturation \%}) + 0.2 * (\text{DI Soluble Silicon}) - 18.4 * \left(\frac{\text{Oxygen \%}}{\text{Carbon \%}} \right)$$



What we want from our biochar:

- Milled
- High water sorption capacity, but low ambient moisture
- Low O/C
- High soluble silicon



Biochar cementitious composites

What's the feasibility of a carbon negative solution?

Mix	OPC \$150/ mt	Biochar \$275- \$750/mt	Fly Ash \$80/mt	Cost/yd \$275/mt biochar	Cost/yd \$500/mt biochar	Cost/yd \$750/mt biochar	Cost compared to Base	Strength Compared to Base
Base	100%	--	--	\$ 71.90	\$ 71.90	\$ 71.90	100%	100%
33% BC	67%	33%	--	\$ 84.80	\$ 103.30	\$ 123.90	118 - 172%	101%
20% BC, 40% FA	40%	20%	40%	\$ 70.45	\$ 81.70	\$ 94.20	98 - 131%	tbd



Thank you!

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