TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

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DEPARTMENT OF TRANSPORTATION · UNITED STATES GOVERNMENT

Soil State Dependency of Carbonation for Rapid Strength Improvement

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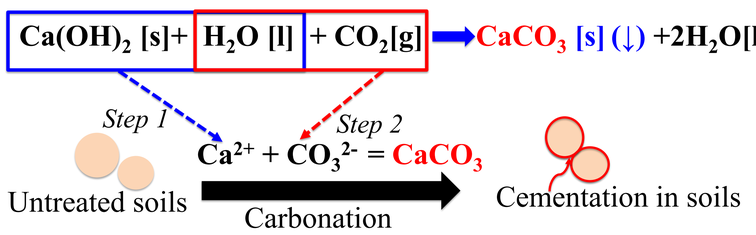
1. Motivation/Background

- ❖Advance novel methods to generate rapid gains in strength for soil improvement—which may be applied to new and/or existing infrastructure
- ❖Potential to reduce construction costs and schedule (e.g. conventional lime stabilization via pozzolanic reaction is slow)
- ❖Use materials and waste byproducts that reduce the high carbon footprint imposed by industry (e.g. cement/lime production involves high energy consumption and CO_2 gas emissions)

2. Accelerated soil carbonation-a more sustainable approach

Reaction mechanism for soil strength improvement

- ❖ Introducing CO_2 gas into soil in presence of water and alkaline
- ❖ Most often soil is alkali deficient which requires to add any alkaline source [e.g. lime, $Ca(OH)_2$] with soil before carbonation



Note: s=solid, l=liquid, aq=aqueous=dissolved in water, g=gas, ↓=deposited

Potential benefits

- ❖Utilize waste CO_2 gas captured from industry and production of lime itself to enhance sustainability (i.e. carbon sequestration)
- ❖Rapid soil stabilization (i.e. reduction in construction cost and time)

3. Laboratory investigation

Objectives

- ❖Understand the relative influence of initial water content and density/void ratio on strength and binder formation (degree of carbonation) of lime mixed granular soils

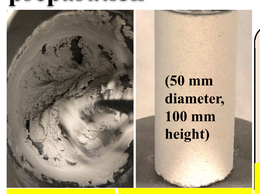
Soil type: Sand; Lime content: 10% (by weight); Carbonation time: 3-120 hours

Testing

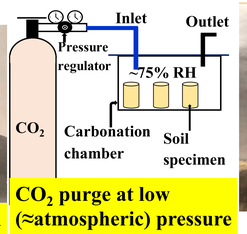
- ❖Unconfined compressive strength (UCS)
- ❖Thermogravimetric analyses (TGA)

4. Methodology

Mixing and specimen preparation

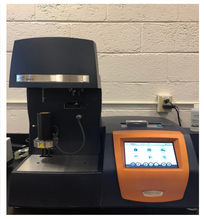


Soil carbonation



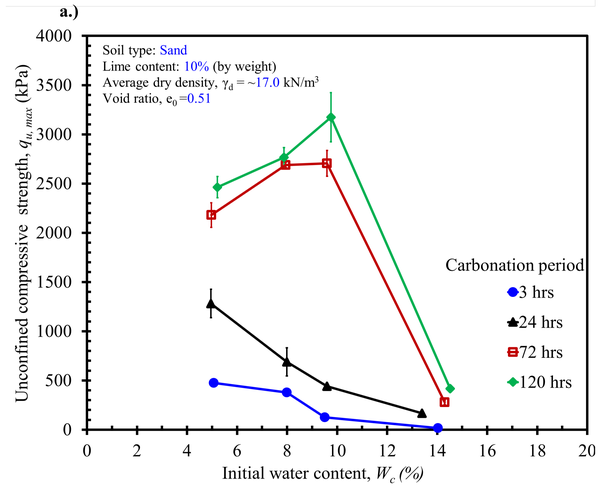
UCS

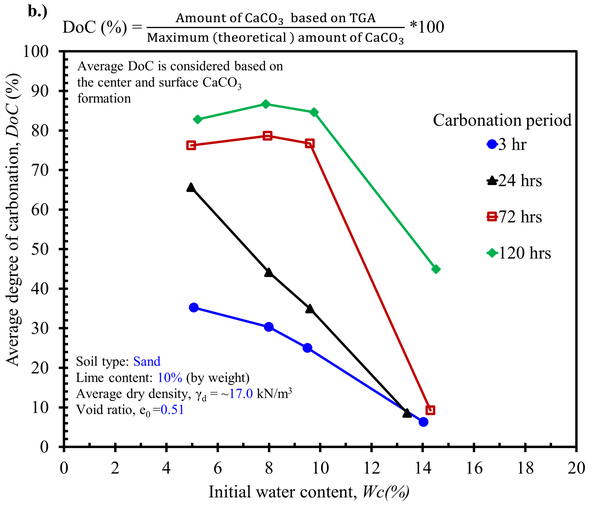
TGA



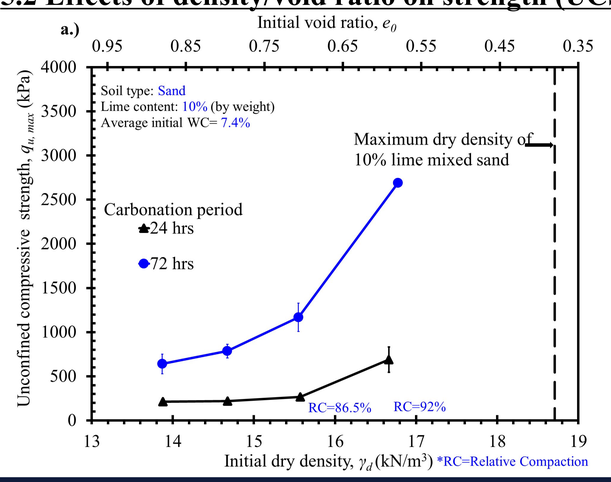
5. Results

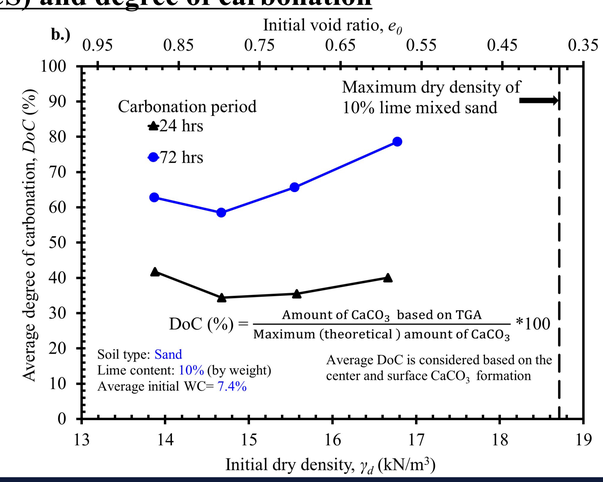
5.1 Effects of water content on strength (UCS) and degree of carbonation



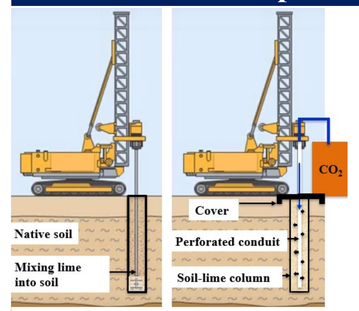


5.2 Effects of density/void ratio on strength (UCS) and degree of carbonation



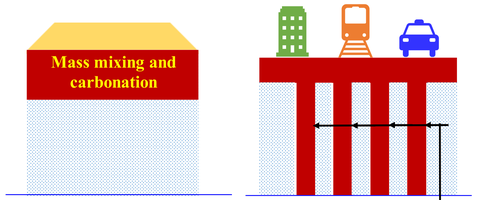


7. Possible field implementation and application



Deep mixing carbonation using existing tools

Step 1-Mixing alkaline (e.g. lime) into ground; Step 2- Permeation of CO_2



6. Summary/conclusions

- ❖Accelerated carbonation of lime mixed granular soils at low pressure is an emerging alternative for rapid stabilization of soils.
- ❖ Rate of carbonation and strength improvement is dependent on initial state of soil such as water content and density/void ratio for a particular lime content
- ❖Degree of carbonation (DoC) is strongly correlated with initial WC. The strength in general increases with increasing DoC, and maximum UCS as high as **3 MPa** is achieved with DoC **80%.**
- ❖Strength of carbonated soil at constant WC is highly dependent on initial density. The UCS is reduced by more than 50% when density of lime mixed sand is decreased by 10 % (i.e. 16.8 to 15.6 kN/m^3)

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