Soil State Dependency of Carbonation for Rapid Strength Improvement

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Abstract

Accelerated soil carbonation has been proved to be a promising ground improvement alternative for rapid stabilization of subgrade materials. This process requires introduction of carbon dioxide (CO_2) gas that reacts with alkaline minerals, for example, calcium oxide and/or magnesium oxide. These alkaline minerals can be present in naturally occurring soil or added to the soil. The chemical reaction between alkaline minerals and CO_2 in the presence of moisture forms stable carbonate minerals which act as binding agents in the soil matrix and increase the strength and stiffness of subgrade materials. The rapid strength improvement and rate of binder formation (i.e. degree of carbonation) are mainly influenced by alkaline content, carbonation period, CO_2 pressure, and initial soil state, such as water content and density/void ratio. However, the effects of soil state on carbonation using calcium based alkaline have rarely been investigated. This study investigated the potential of carbonation at atmospheric pressure for rapid stabilization of sand using lime (calcium hydroxide) as an alkaline source. Specifically, the relative influences of initial water content and density of the soil-lime mix on the carbonation induced soil stabilization process was analyzed. The strength improvement of treated soils was determined through unconfined compressive strength (UCS) tests and the binder formation was quantified using Thermogravimetric Analysis (TGA). Results revealed that the rate of carbonation and rapid strength improvement are highly dependent on initial water contents and density of soil-lime mixes. The UCS of carbonated sand mixed at 10% lime can achieve as high as 3 MPa with a degree of carbonation about 80% in 72-120 hours. However, the strength is decreased by more than 50% when the density is reduced by 10% from its initial density (i.e. around 17 kN/m^3).

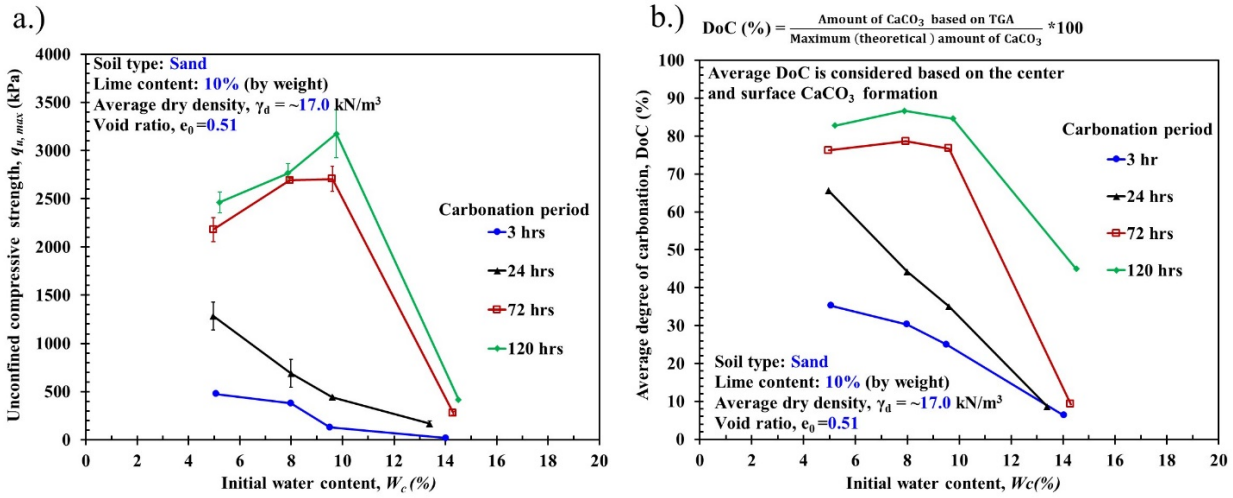

Figure 1. Effects of initial water content on a.) carbonated soil strength, and b.) degree of carbonation of 10% (by weight) lime-mixed sand specimens prepared at constant density/void ratio

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