A Large-Scale Demonstration of Soil Carbonation for Stabilization of Subgrade Soils

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Abstract

Challenging subsurface conditions most often demand soil stabilization to modify the in-situ properties of subgrade soils for any kind of civil infrastructure development. Chemical stabilization, one of the most common techniques to stabilize shallow subgrade soils, involves field mixing of cement and/or lime with in-situ soils to create a binder that improves the strength and stiffness of subgrade soils. Accelerated soil carbonation is an alternative to conventional chemical stabilization methods whereby, carbon dioxide gas is introduced into alkali [e.g. hydrated lime, $Ca(OH)_2$] mixed soils and consumed instantaneously via chemical reaction to produce carbonate binder that precipitates and cements soils. Soil carbonation showed promising results to improve the soil strength and stiffness on the elemental scale. Therefore, a large-scale demonstration was conducted utilizing a novel carbonation method [Figure 1] to verify that soil carbonation can improve the strength/stiffness of soils to a practical depth generally involved with roadway subgrade stabilization. Additionally, freeze-thaw (F-T) durability of carbonated frost-susceptible soils was investigated by applying two F-T cycles in an environmental chamber under the most severe field conditions (1-D freezing-front through surface of the roadway with continuous supply of water from the bottom of the subgrade soil layer) [Figure 2]. The strength improvement and carbonate biner content were determined via field California Bearing Ratio (CBR) testing and thermogravimetric analysis (TGA). Experimental results revealed that the proposed carbonation method was effective to improve the top 150 mm (6-inch) of subgrade soil layer, and the improved subgrade (carbonated soil layer) was durable under freeze-thaw conditions. These results are highly encouraging in terms of relatively faster mechanical improvement of subgrade soils, and carbon dioxide gas consumption to reduce the carbon emission associated with production of soil stabilizing agents (cement/lime).

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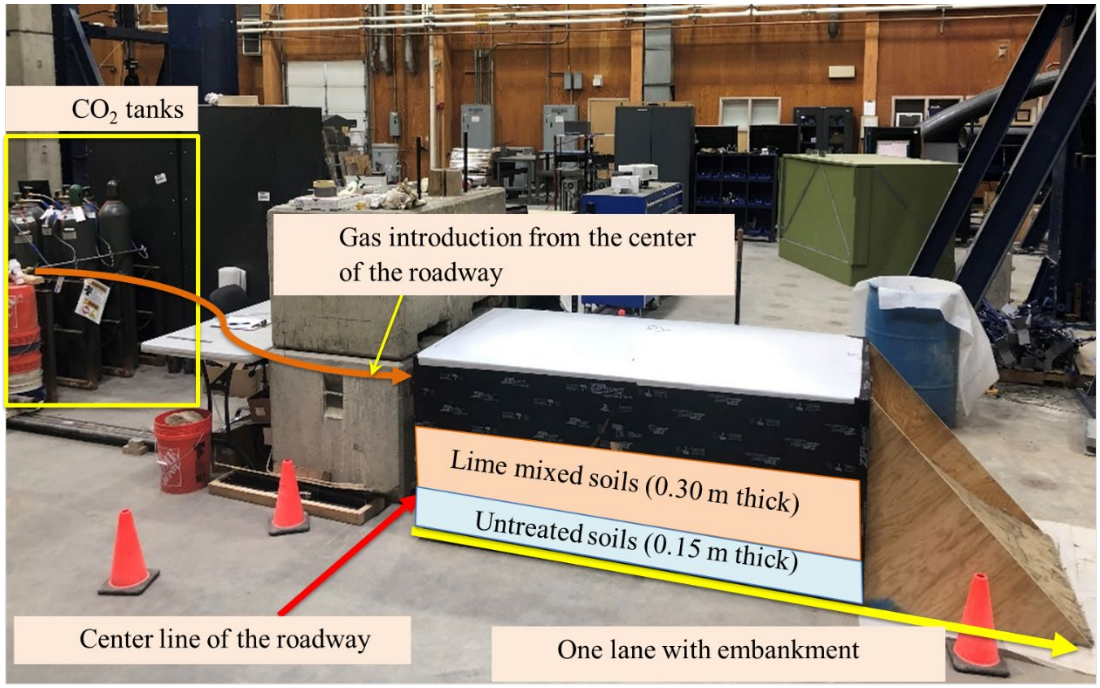

Figure 1. A novel soil carbonation method (introducing carbon dioxide gas to the surface of the subgrade soil at low CO_2 pressure by covering the roadway using plastic tarp) to stabilize shallow subgrade soils mimicking a half-embankment in a large box (1-m in length and 2-m in width).

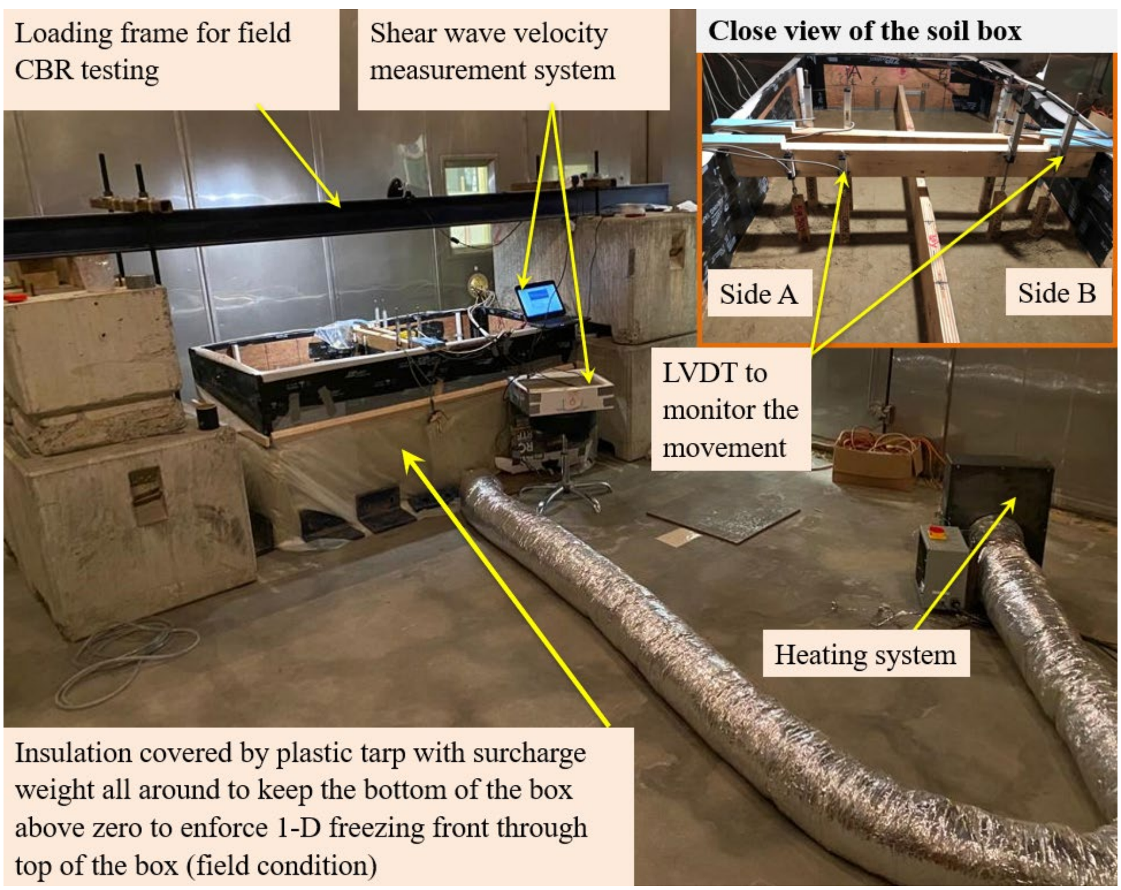

Figure 2. An overview of freeze-thaw experiment inside a temperature and humidity controlled environmental chamber at the Advanced Structures and Composites Center, ASCC UMaine.