Quarterly Progress Report:
Project Number and Title: 2.9: Carbonating Subgrade Materials for In-Situ Soil Stabilization
Research Area: New Materials for Longevity and constructability
PI: Aaron Gallant, Ph.D., P.E., University of Maine
Co-PI(s): Warda Ashraf, Ph.D., University of Texas at Arlington
Reporting Period: 4/1/2020-6/30/2020
Submission Date: 6/30/2020

Overview: (Please answer each question individually)

*Provide **BRIEF** overview and summary of activities performed during the reporting period. This summary should be written in lay terms for a general audience to understand. This should not be an extensive write up of findings (those are to be included in the final report), but a high-level overview of the activities conducted during the last three months **no more than 3 bullet points no more than 1 sentence each** ….*

Carbonation of lime mixed soil is a chemical reaction between lime and carbon dioxide in water. This process can rapidly stabilize the soils through formation of carbonate binders in the soil matrix. The previous results and extensive literature review revealed that rapid carbonation and associated strength (mechanical) gain is dependent on various interdependent factors as summarized in Figure 1. It is also identified that the soil compaction at optimum water content and maximum dry density (i.e. lowest porosity/void ration) is not the best condition for optimum carbonation and binder formation. In other words, initial soil-lime mix condition combining both mechanical compaction and chemical reaction need to be considered for soil stabilization via carbonation in terms of field implementation. Therefore, we extended our elemental testing focusing on effects of initial water content and void ratio on soil carbonation at low CO_2 pressure considering three different soil types. However, the works in the past there months had been interrupted due to COVID-19 and we did not obtain the full picture on effects of initial state of soil on carbonation and rapid strength gain. Meanwhile, we made a significant progress on preparing a manuscript (full article) based on the preliminary results. Upon completion of the planned mechanical and microstructural tests, we are hoping to submit it for possible publication.

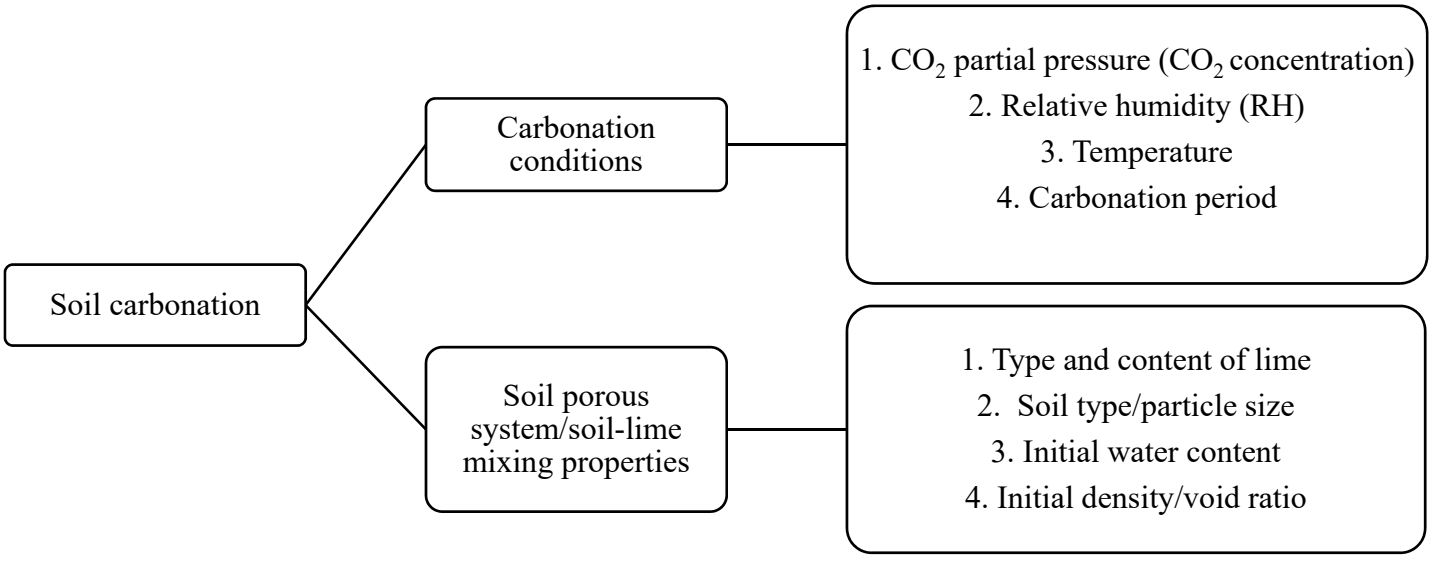

Figure 1. Factors influencing rate of soil carbonation and rapid strength improvement

Provide context as to how these activities are helping achieve the overarching goal(s) of the project…

Elemental testing as part of Phase I of this project is being performed to characterize the factors contributing to soil carbonation and associated strength for different soil types to gain rapid strength. It would provide a framework on designing large scale laboratory testing and field trial for optimum conditions for soil stabilization via carbonation.

Describe any accomplishments achieved under the project goals…

One peer-reviewed conference paper has been published in Geo-Congress 2020: Foundations, Soil Improvement, and Erosion under Geotechnical Special Publication No. 315, Geo-Institute (G-I) of the American Society of Civil Engineers (ASCE). Additionally, a poster presentation, titled *Rapid Stabilization of Non-plastic Granular Soils via Carbonation* has been made in Geo-Congress 2020 in Minneapolis, MN on February 26.

Complete the following tables to document the work toward each task and budget (add rows/remove rows as needed, make sure you complete the Overall Project progress row and include all tasks even if they have ended or have not been started)…

Table 1: Task Progress

Task Number	Start Date	End Date	% Complete
Task 1: Literature Review	September 2018	Ongoing	100% to date
Task 2: Elemental testing	December 2018	July 2020	80%
Task 3: Pseudo Field-Scale Trial (Laboratory soil box)	August 2020	March 2021	0%
Overall Project:	September 2018	August 2021	45%

Table 2: Budget Progress

Project Budget	Spend – Project to Date	% Project to Date*

Include the date the budget is current to.

Describe any opportunities for training/professional development that have been provided…

N/A

Describe any activities involving the dissemination of research results (be sure to include outputs, outcomes, and the ways in which the outcomes/outputs have had an impact during the reporting period. Please use the tables below for any Publications and Presentations in addition to the description of any other technology transfer efforts that took place during the reporting period)… Use the tables below to complete information about conferences, workshops, publications, etc. ***List all other outputs, outcomes, and impacts after the tables*** *(i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings).*

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events

Title	Event	Type	Location	Date(s)

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
Peer-reviewed conference paper	Elemental testing of carbonated silty sand treated with lime	Hossen, S. B., Gallant, A. P., & Ashraf, W. (2020). Elemental Testing of Carbonated Silty Sand Treated with Lime. *Geo-Congress 2020*, ASCE GSP 315, Minneapolis MN, pp. 562-571.	February 21, 2020	Published
Peer-review Journal	Influence of initial soil state parameters on rapid strength gain	Hossen, S. B., Gallant, A. P., & Ashraf, W. (2020). Influence of initial soil state parameters on rapid strength gain of granular soils under low CO_2 pressure conditions. *Can. Geotech. J.*, (In preparation).	-	In preparation

	of granular soils under low CO_2 pressure conditions			

Participants and Collaborators:

Use the table below to list all individuals who have worked on the project.

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
Aaron Gallant, PhD, PE	aaron.gallant@maine.edu	Civil Engineering, University of Maine	PI
Warda Ashraf, PhD	warda.ashraf@uta.edu	Civil Engineering, UT Arlington	Co-PI

Use the table below to list all students who have participated in the project during the reporting. (This includes all paid, unpaid, intern, independent study, or any other student that participated in this project.)

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
SK Belal Hossen		PhD	Civil and geotechnical engineering	Graduate Research Assistant

Use the table below to list any students who worked on this project and graduated during this reporting period. N/A

Table 7: Student Graduates			
Student Name	**Role in Research**	**Degree**	**Graduation Date**

Use the table below to list organizations have been involved as partners on this project and their contribution to the project. N/A

Table 8: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**

List all other outputs, outcomes, and impacts here (i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings). Please be sure to provide detailed information about each item as with the tables above. N/A

Have other collaborators or contacts been involved? If so, who and how? (This would include collaborations with others within the lead or partner universities; especially interdepartmental or interdisciplinary collaborations.) N/A

Table 9: Other Collaborators			
Collaborator Name and Title	**Contact Information**	**Organization and Department**	**Contribution to Research**
			(i.e. Technical Champion)

Who is the Technical Champion for this project?
Name: Dale Peabody
Title: Director of Transportation Research
Organization: MaineDOT
Location (City & State): Augusta, ME
Email Address: dale.peabody@maine.gov

Changes:

Discuss any actual or anticipated problems or delays and actions or plans to resolve them…
Discuss any changes in approach and the reasons for the change…

COVID-19 has interrupted testing program for all phases of research. We are entering the lab in July to resume testing and preparation for soil box testing.

Planned Activities:

Description of future activities over the coming months.
We plan to conduct two series of tests that will include mechanical and TGA testing to verify our hypothesis that rapid gains in strength may be achieved under low CO_2 pressure conditions, and for a wider range of soil types than initially thought based on preliminary testing. We intend to focus on the influence of initial state (water content, dry density/void ratio) and will investigate three soil types that cover a wide range of soil types encountered in the field (sand, silty sand and silt). This will inform our understanding of requisite conditions necessary for carbonation to be successful in the field.