

Quarterly Progress and Performance Indicators Report:

Project Number and Title: 3.13: Investigating the Effectiveness of Enzymatic Stabilizers for Reclaimed Stabilized Base Projects

Research Area: Thrust # 3, New systems for longevity and constructability

PI: *Ehsan Ghazanfari, The University of Vermont*

Co-PI(s): *Mandar Dewoolkar, The University of Vermont*

Reporting Period: 7/1/2022 to 9/30/2022

Submission Date: 9/30/2022

Overview:

The overarching goal of this project is to evaluate the effectiveness of enzymatic stabilizers in RSB projects in Vermont and the NE region. During the past quarter, we continued investigation of the use of biopolymers in roadway subbase. The range of biopolymer content has been expanded to include proportions from 0.1% to 4.0% by mass. Two roadway subbase materials are being used include a lab-created material that generally adheres to regional DOT's gradation requirements for subbase and an RSB material from an active VTrans project. In addition to unconfined compressive strength testing, hydraulic conductivity measurement of Xanthan Gum (XG) treated soil was attempted, however the jellification and swelling of the XG resulted in clogging of the pore spaces in the soil matrix inhibiting flow the of water. Surface gas permeability was conducted instead. The findings suggest that increased XG content generally results in lower surface gas permeability. Testing of subbase treated with 2.0% and 4.0% XG is currently underway. Ongoing work includes investigation of the efficacy of microbially-induced calcite precipitation (MICP) for subbase stabilization. A new percolation technique is being used to treat the specimens; however current findings suggest that the technique requires further attention in order to produce the desired level of calcite cementation. The performed work in previous months helps us move closer toward the next steps of the project in evaluating the effectiveness of the enzymatic stabilizers in RSB projects and determining the appropriate enzymatic agent for the type of base/subbase material encountered in different RSB projects.

Task, Milestone, and Budget Progress:

Table 1: Task Progress			
Task Number: Title	Start Date	End Date	% Complete
Task 1: Prepare specimens with enzymatic stabilizing agents	1/1/2021	11/1/2021	60%
Task 2: Evaluate the strength and stiffness improvement and hydraulic response of prepared specimens	1/1/2021	3/31/2022	55%
Task 3: Investigate the mechanism of strength improvement and develop design parameters	2/1/2022	8/31/2022	50%
Task 4: Perform relatively large-scale laboratory tests and/or field tests to evaluate the performance of enzymatic stabilizers	9/1/2022	8/1/2023	0%
Task 5: Provide a set of recommendations and develop guidelines for implementation	1/1/2023	8/31/2023	0%
Overall Project	1/1/2021	8/31/2023	55%

Table 2: Milestone Progress

Milestone #: Description	Corresponding Deliverable	Start Date	End Date
Prepare specimens with enzymatic stabilizing agents	Report/presentation to TAC	9/1/2020	1/31/2021
Prepare and cure specimens with various enzymatic stabilizing agents and various percentages	Report/presentation to TAC and TIDC	2/1/2021	11/1/2021
Evaluate the strength-gain (UCS) of prepared specimens	Report/presentation to TAC and TIDC	1/1/2021	7/31/2021
Evaluate the UCS, shear strength, stiffness and permeability of specimens with various enzymatic stabilizing agents and various percentages	Report/presentation to TAC, TIDC, semi-annual report supplement	8/1/2021	3/31/2022
Investigate the mechanism of strength improvement in stabilized specimens	Report/presentation to TAC, TIDC	2/1/2022	5/31/2022
Develop design parameters for enzymatic stabilization	Report/presentation to TAC, TIDC, semi-annual report supplement	6/1/2020	8/31/2022
Perform large-scale laboratory and field tests to evaluate the performance of enzymatic stabilizers	Report/presentation to TAC, TIDC	9/1/2022	8/1/2023
Provide a set of recommendations and develop guidelines for implementation	Report/presentation to TAC, TIDC, semi-annual report supplement	1/1/2023	8/31/2023

Table 3: Budget Progress

Project Budget	Spend – Project to Date	% Project to Date (include the date)
\$538,278	\$ 319,889.41	59.4%

Is your Research Project Applied or Advanced?

- Applied** *(The systematic study to gain knowledge or understanding necessary for determining the means by which a recognized and specific need may be met.)*
- Advanced** *(An intermediate research effort between basic research and applied research. This study bridges basic (study to understand fundamental aspects of phenomena without specific applications in mind) and applied research and includes transformative change rather than incremental advances. The investigation into the use of basic research results to an area of application without a specific problem to resolve.)*

Education and Workforce Development:

Answer the following questions (N/A if there is nothing to report):

Did you provide any workforce development or training opportunities to transportation professionals (already in the field)? If so, what was the training? When was it offered? How many people attended? No

1. Did you hold meetings with any transportation industry organizations or DOTs? If so, what was the meeting’s purpose? When was it offered? How many people attended? (i.e. The research team held a meeting with MaineDOT to update them on the progress of the research findings and how the findings can be implemented on 3/31/2021. 15 DOT maintenance members were present at the meeting.)
No
2. Did you host/participant in any K-12 education outreach activities? If so, what was the activity? What was the target age/grade level of the participants? How many students/teachers attended? When was the activity held? (i.e. 25 8th graders and 2 teachers visited the concrete lab and created small concrete trinkets like Legos on 3/31/2021. They learned about the different types of fibers that can be used in the concrete.)
No

Technology Transfer:

Table 4: Presentations at Conferences, Workshops, Seminars, and Other Events

Type	Title	Citation	Event & Intended Audience	Location	Date(s)
i.e. Conference, Symposium, DOT/AOT presentation, Seminar, etc.	Presentation Title	Full Citation	Name of event (i.e. TIDC 1 st Annual Conference) or who was the presentation given to?		
Conference	Xanthan Gum Biopolymer for Road Subbase Stabilization	Poster	4th Annual Transportation Infrastructure Durability Conference	University of Maine	8/9 to 8/11 2022

Table 5: Submitted/Accepted Publications, Technical Reports, Theses, Dissertations, Papers, and Reports

Type	Title	Citation	Date	Status
i.e. Peer-reviewed journal, conference paper, book, policy paper, magazine/newspaper article	Publication title	Full citation		i.e. Submitted, accepted, under review (by org. submitted to)
TRB Annual Meeting	Investigating the use of Xanthan Gum in Roadway Subbase Stabilization	van der Heijden, R., Ghazanfari, R., Dewoolkar, M. (2022). Investigating the use of Xanthan Gum in Roadway Subbase Stabilization.	8/1/2022	submitted

Answer the following questions (N/A if there is nothing to report):

1. Did you deploy any technology during the reporting period through pilot or demonstration studies as a result of this work? If so, what was the technology? When was it deployed?
No
2. Was any technology adopted by industry or transportation agencies as a result of this work? If so, what was the technology? When was it adopted? Who adopted the technology?
No
3. Did findings from this research project result in changing industry or transportation agency practices, decision making, or policies? If so, what was the change? When was the change implemented? Who adopted the change?
N/A
4. Were any licenses granted to industry as a result of findings from this work? If so, when? To whom was the license granted?
No
5. Were any patent applications submitted as a result of findings from this research? If so, please provide a copy of the patent application with your report.
No
6. Did industry organizations or DOTs provide cost-share (cash or in-kind) to your research during the reporting period? Who was the organization? Please provide an in-kind support invoice from the organization with your report (this is kept confidential and used for record keeping purposes only).
Yes, Vermont Agency of Transportation

Outputs:

Research is ongoing.

Outcomes:

Research is ongoing.

Impacts:

Research is ongoing

Participants and Collaborators:

Table 6: Active Principal Investigators, faculty, administrators, and Management Team Members				
Individual Name & Title	Dates involved	Email Address	Department	Role in Research
Ehsan Ghazanfari	1/1/2021-present	Ehsan.ghazanfari@uvm.edu	Civil & Environmental Engineering	Principal Investigator
Mandar Dewoolkar	1/1/2021-present	Mandar.Dewoolkar@uvm.edu	Civil & Environmental Engineering	Co-Principal Investigator

Table 7: Student Participants during the reporting period								
Student Name	Start Date	End Date	Advisor	Email Address	Level	Major	Funding Source	Role in research
Ryan van der Heijden	1/9/2021	Cont.	Ghazanfari and Dewoolkar		Ph.D.	Civil & Environmental Engineering	TIDC	Graduate Research Assistant

Table 8: Students who Graduated During the Reporting Period			
Student Name	Degree/Certificate Earned	Graduation/Certification Date	Did the student enter the transportation field or continue another degree at your university?
None			Please list the organization or degree

Table 9: Industrial Internships			
Student Name	Degree/Certificate Earned	Graduation/Certification Date	Did the student enter the transportation field or continue another degree at your university?
None			Please list the organization or degree

Table 10: Research Project Collaborators during the reporting period						
Organization	Location	Contribution to the Project				
		Financial Support	In-Kind Support	Facilities	Collaborative Research	Personnel Exchanges
None						

Table 11: Other Collaborators

Collaborator Name and Title	Contact Information	Organization and Department	Date(s) Involved	Contribution to Research
Callie Ewald, Geotechnical Engineering Manager		Vermont Agency of Transportation	1/1/2021-present	Technical Advisory Committee Chair

Table 12: Course List

Course Code	Course Title	Level	University	Professor	Semester	# of Students
None						

Changes:

None

Planned Activities:

continue preparing, curing, and testing specimens stabilized with enzymatic stabilizing agents