

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: 1/10/2021 to 12/31/2021

Submission Date: 12/31/2021

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 prepared, cured and tested sub-base soil specimens stabilized with Xanthan Gum (XG), in the laboratory and continued the literature review on using enzymatic stabilizers in reclaimed stabilized base (RSB) projects to improve stabilization outcome. Specimens were prepared using standard proctor compaction at the optimum moisture content. XG was added to the dry soil prior to addition of water at 0.5, 1.0, 2.0, 3.0, and 4.0% of the dry soil mass. Specimens were cured at room temperature and humidity for 7, 14, and 28-day periods. For all XG proportions, the uniaxial compressive strength increased with longer curing durations. In addition, the stiffness of cured specimens increased and appeared to predominantly be a function of curing time. SEM imaging was carried out on a specimen that was prepared using glass beads (100-170 μm diameter) with 1.0% XG and oven-dried to allow for ease of imaging. SEM images revealed a coating around the glass beads and “connectional bridges” between the beads, bridging between particles and binding them. We are continuing laboratory testing using different stabilizers and various gradations to better understand the mechanism of strength improvement and assess the effectiveness of the stabilizers. 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	30%
Task 2: Evaluate the strength and stiffness improvement and hydraulic response of prepared specimens	1/1/2021	3/31/2022	25%
Task 3: Investigate the mechanism of strength improvement and develop design parameters	2/1/2022	8/31/2022	25%
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	20%

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	\$96,330	17.9%

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):

1. 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? (i.e. The research team provided an in the field training for the SAR technology for 3 maintenance crew members of the MassDOT on 3/31/2021. The members learned how to use the technology and interrupt the data.)
No

2. 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

3. 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?		
None					

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)
None				

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	callie.ewald@vermont.gov	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 sub-base soil specimens stabilized with enzymatic stabilizing agents