Quarterly Progress and Performance Indicators Report:
Project Number and Title: C7.2018: Alternative Cementitious Materials (ACMs) For Durable and Sustainable Transportation Infrastructures
Research Area: New Materials for Longevity and Constructability
PI: *Professor Eric N. Landis, Ph.D., University of Maine*
Postdoctoral Research Associate: *Hosain Haddad Kolour, Ph.D., PE, University of Maine*
Reporting Period: *7/1/2021-9/30/2021)*
Submission Date: *30 Sep 2021*

******IMPORTANT: Please fill out each section fully and reply with N/A for questions/sections with nothing to report. For ease of reporting to the USDOT, please do not remove, or change the order of, any sections/text. You may remove/add each rows in tables as needed. Thank you! ******
The report is due on the last day of the reporting period in .doc format to tidc@maine.edu.

Overview:

*Provide **BRIEF** highlights 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 at no more than 1 sentence each** ….*

- Some free shrinkage and electrical resistivity tests have been conducted to verify the previous results.
- All done with tests. Now we are working on interpreting the results and writing the report.

Meeting the Overarching Goals of the Project:

How did the previous items help you achieve the project goals and objects? Please give one bullet point for each bullet point listed above.

- Verifying results was necessary for project completion
- Interpreting results is necessary for writing report

Accomplishments:

List any accomplishments achieved under the project goals in bullet point form…

- Results verification

Task Progress and Budget:

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: Title	**Start Date**	**End Date**	**% Complete**
Task 1: Selection of ACM with desired workability and strength	06/01/2019	12/31/2019	100%
Task 2: Shrinkage	01/01/2020	01/01/2021	100%
Task 3: Durability performance	10/01/2019	06/31/2021	100%
Task 4: Service life performance	10/01/2020	06/31/2021	100%

Table 2: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date (include the date)**
$83,238 (from UTC)	Information is coming soon	

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.)*

Professional Development/Training Opportunities:

Describe any opportunities for training/professional development that have been provided. Did you provide a training to a State DOT/AOT or industry organization? What was the training? When was it offered? How many people attended? Did you meet with a State DOT/AOT or industry organization to inform them of your findings and how these findings could help their organization? When? How many attended the meeting?

- One postdoctoral research associate is working in this project. It will be a great opportunity for him to learn about writing proposals, preparing reports, participating in meeting, attending conferences, and working with professionals in UTC, UMaine Advanced Structures and Composites Center, and MaineDOT.
- Three undergraduate students have been involved in this project. It will be a great experience for them to be familiar with ASTM tests and standards. They will learn how to conduct the experiments, how to follow the standards, and how to work in a team in a real project.
- Usually five to ten engineers participate in our regular meetings with Maine DOT engineers

Technology Transfer:

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? N/A

2. Was any technology adopted by industry or transportation agencies as a result of this work? If so, what was the technology? When was is adopted? Who adopted the technology? N/A

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? N/A

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. N/A

6. Based on project results, were any industrial contracts awarded for additional research and development activities? If so, when? How much was awarded? Who awarded the contract? N/A

Please add figures/images that can be included on the website and/or in marketing/social media materials to further clarify your research to the general public.

Insert figures here

Describe any additional activities involving the dissemination of research results not listed above under the following headings:

Outputs:

Definition: Any new or improved process, practice, technology, software, training aid, or other tangible product resulting from research and development activities. They are used to improve the efficiency, effectiveness, and safety of transportation systems. List any outputs accomplished during this reporting period:

- In this project, two Alternative Cementitious Materials (ACMs) systems were evaluated: (I) CO_2 activated binders and (II) alkali-activated binders. Local cementitious materials (Cement and Slag produced in Maine, Thomaston) and aggregates (from Old Town, Maine) tested for improving concrete properties. Compressive Strength Tests were used for evaluating mechanical strength properties. Bulk and Surface Electrical Resistivity tests were conducted for measuring transport properties. Free shrinkage tests were performed for understanding the shrinkage properties. Slump tests were conducted to study workability.

- Current MaineDOT standard (2020 MaineDOT Standard Specifications) recommends concrete permeability control based on minimum surface resistivity (minimum 14 KOhm-cm for class A concrete and minimum 17 KOhm-cm for class LP concrete). Our research showed that using surface electrical resistivity is not a good criterion for permeability control. Because surface resistivity includes both concrete resistivity and pore solution resistivity. This study showed that instead of surface resistivity, "Formation Factor" should be used for quality control (transport property) of concrete.
- Also, in shrinkage tests, we showed that other state DOTs are working on setting a limit for free shrinkage of concrete based on its application. We recommended MaineDOT to work on this. Next research subject could be finding some recommended limits for free shrinkage of concretes in MaineDOT projects.

Outcomes:

Definition: The application of outputs; any changes made to the transportation system, or its regulatory, legislative, or policy framework resulting from research and development activities. List any outcomes accomplished during this reporting period:

- Our hope is that current MaineDOT standard (2020 MaineDOT Standard Specifications) will be modified following our research. This study recommends using "Formation Factor" for permeability/durability control. Also, it could be useful if we set some restrictions for free shrinkage of concrete based on its application. Finding these limits needs more investigations.

Impacts:

Definition: The effects of the outcomes on the transportation system such as reduced fatalities, decreased capital or operating costs, community impacts, or environmental benefits. The reported impacts from UTCs are used for the assessment of each UTC and to make a case for Federal funding of research and education by demonstrating the impacts that UTC funding has had on technology and education. NOTE: The U.S. DOT uses this information to assess how the research and education programs (a) improve the operation and safety of the transportation system; (b) increase the body of knowledge and technologies; (c) enlarge the pool of people trained to develop knowledge and utilize technologies; and (d) improves the physical, institutional, and information resources that enable people to have access to training and new technologies. List any outcomes accomplished during this reporting period:

- During our regular meeting with MaineDOT engineers, we introduced these two relatively new technologies: (I) CO2 activated binders and (II) alkali-activated binders. Specially using CO_2 for improving concrete properties was very interesting for them and for TIDC. We helped TIDC in organizing a panel discussion "Durable Low Emission Concrete: A Road Map" in 2021 Transportation Infrastructure Durability Conference (July 2021). Following our study, UMaine Advanced Structures and Composites Center planned to hire an assistant research professor in concrete focusing on lower CO_2 concrete.

- Also, we introduced "Formation Factor" and its application in quality control of concrete to MaineDOT engineers. Hopefully using Formation Factor rather than surface resistivity will be popular in MaineDOT projects. Setting some recommended limits for free shrinkage was another suggestion for MaineDOT.

- Using ACMs, CO_2 activation technology, alkali activation technology, and suggestions/recommendations from this investigation, can decrease costs and leads to considerable environmental benefits for MaineDOT concrete projects.

Participants and Collaborators:

Use the table below to list individuals (compensated or not) who have worked on the project other than students.

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members				
Individual Name & Title	**Dates involved**	**Email Address**	**Department**	**Role in Research**
Professor Eric N. Landis	03/01/2020	*landis@maine.edu*	*Civil and Environmental Engineering*	*PI*
Dr. Hosain Haddad Kolour	03/01/2020	*hosain.haddad@maine.edu*	*Civil and Environmental Engineering*	*Perform the experiments and analysis the results*

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

Table 6: Student Participants during the reporting period								
Student Name	**Start Date**	**End Date**	**Advisor**	**Email Address**	**Level**	**Major**	**Funding Source**	**Role in research**
Alexander Baur	1/6/21	8/30/21	Professor Eric N. Landis		UG	Civil and Environmental Engineering	TIDC	Help in performing the experiments
Tanner Laflamme	1/6/21	8/30/21	Professor Eric N. Landis		UG	Civil and Environmental Engineering	TIDC	Help in performing the experiments
Emma White	1/6/21	8/30/21	Professor Eric N. Landis		UG	Civil and Environmental Engineering	TIDC	Help in performing the experiments

*Use the table below to list **organizations** that have been involved as partners on this project and their contribution to the project.*

Table 9: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
University of Maine	Maine	x	x	x		
Miane DOT	Miane				x	

*Use the table below to list **individuals** that have been involved as partners on this project and their contribution to the project.*
*(**List your technical champion(s) in this table.** This also includes collaborations within the lead or partner universities who are not already listed as PIs; especially interdepartmental or interdisciplinary collaborations.)*

Table 10: Other Collaborators

Collaborator Name and Title	Contact Information	Organization and Department	Date(s) Involved	Contribution to Research
Dale Peabody	Dale.Peabody@maine.gov	Maine DOT	03/01/2020 - Present	Technical advisory board
Joseph Stilwell	Joseph.R.Stilwell@maine.gov	Maine DOT	03/01/2020 - Present	Technical advisory board
Taylor Clark	Taylor.Clark@maine.gov	Maine DOT	03/01/2020 - Present	Technical advisory board
Richard Myers	Richard.E.Myers@maine.gov	Maine DOT	03/01/2020 - Present	Technical advisory board
Lamont Dutra	Lamont.Dutra@maine.gov	Maine DOT	03/01/2020 - Present	Technical advisory board
Michael Redmond	Michael.Redmond@maine.gov	Maine DOT	03/01/2020 - Present	Technical champion

Use the following table to list any transportation related course that were taught or led by researchers associated with this research project:

Table 11: Course List

Course Code	Course Title	Level	University	Professor	Semester	# of Students
CIE 110	Materials	UG	University of Maine	*Professor Eric N. Landis*	Fall 2021	130
CIE 111	Materials Laboratory	UG	University of Maine	*Dr. Hosain Haddad Kolour*	Fall 2021	130

Changes:

- Professor Eric N. Landis is the new PI of this project since January 1st 2020. Both old PI (Dr. Warda Ashraf) and her graduate student (Mohammad Rakibul Islam Khan) moved to a different university.

Planned Activities:

- Interpreting the results. Preparing and writing the report.