Quarterly Progress and Performance Indicators Report:
Project Number and Title: Durability of Modified Helical Piles under Lateral and Torsional Loads: Embracing Efficient Foundation Alternatives to Support Lightweight Transportation Structures
Research Area: Thrust 3
PI: *Aaron Gallant, Assistant Professor, University of Maine*
Co-PI(s): *Maine Keith Berube, Associate Professor, University of Maine; Aaron Bradshaw, Associate Professor, University of Rhode Island*
Reporting Period: *10/1/2021-12/31/2021*
Submission Date: *12/30/2021*

******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** ….*

- In the torsion test it was found that the moment arm and the collar vane flanges displacements were not the same as the applied torque was increased. This is shown in Fig. 1. This slack is due to a non-homogeneous load transfer mechanism in the moment arm-pile-vane system.

- A non-dimensional analysis was implemented to predict the maximum torsional capacity (Tmax) of the wider collar vanes (the ones where failure was not reached).

- The develop of a simplified T-θ (torque-angle) relationships have started. This models how the CV technology beahaves as a torsional load is applied.

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.

- The slack found in torsion test only was found to the wider vanes where the flanges displacements were measured. This can help us to model the moment arm-collar vane relative displacement in the smaller vanes and develop T-θ for all vanes geometries.

- With A known Tmax (specially in the wider vanes) and the data obtained from the field testing, the development of simplified models (T-θ) can be modeled.

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

- Non-dimensional analysis methodology was implemented to predict the maximum torsional capacity of the collar vane. The maximum torque (i.e., the soil failure torque) obtained can be defined as the algebraic sum of the torque values exercised by the prismatic area (upper area of CV) and the tapered area (lower area of CV).

- T-θ (Torque-rotation) curves is developed by using hyperbolic fittings to the values measured in field. The data obtained from field shows that the curves follow a hyperbola function. A hyperbolic fitting is implemented to extrapolate the torque-angle of twist response.

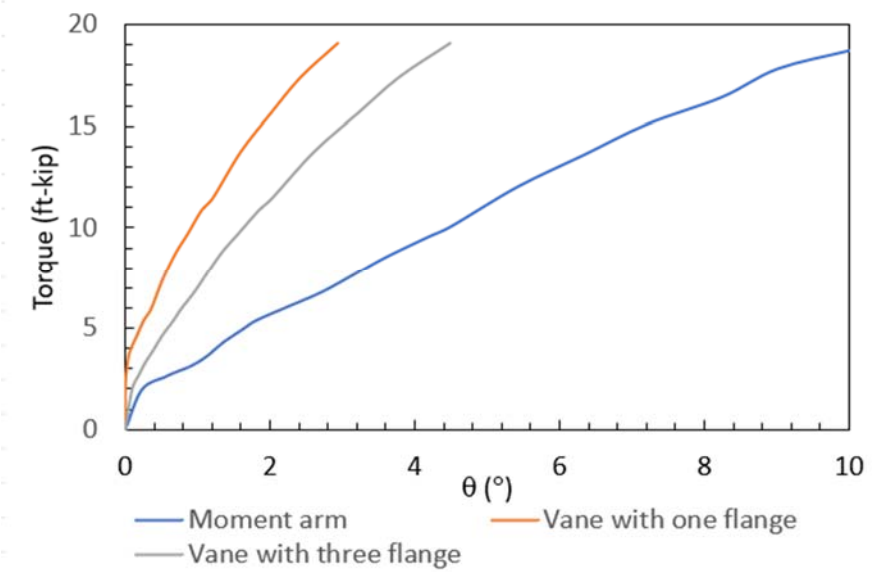

Figure 1. Angle of twist comparison between moment arm and CV flanges. Results for the CV36-36.

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: Acquire instrumentation, prepare install procedures, test DAQ.	January 2021	June 2021	100%
Task 2: Aquire hydraulic jacks, test DAQ.	January 2021	June 2021	100%
Task 3: Collar Vane and HP Manufacturing	January 2021	June 2021	100%
Task 4: Manufacture helical piles, collar vanes, reaction beams, and pile caps.	January 2021	June 2021	100%
Task 5: Full-scale load tests	June 2021	August 2021	80%

Task 6: Develop normalized p-y and T-θ relationships from full-scale field tests	September 2021	February 2022	20%
Task 7: Numerical demonstration of applicability of helical piles to lightweight transportation structures.	September 2021	June 2022	
Task 8: Spring load tests to test seasonal effects.	May 2021	June 2022	0%
Task 9: Final reporting and journal article preparation	January 2022	-	

Table 2: Budget Progress

Project Budget	Spend – Project to Date	% Project to Date (include the date)
Enter Phase 1 Full Budget	Enter Phase 1 Full Spend Amount (Federal + Cost Share)	Enter Phase 1 % Spent
Enter Phase 2 Full Budget	Enter Phase 2 Full Spend Amount (Federal + Cost Share)	Enter Phase 2 % Spent
Enter Phase 3 Full Budget	Enter Phase 3 Full Spend Amount (Federal + Cost Share)	Enter Phase 3 % Spent

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?

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Technology Transfer:

Complete all of the tables below and provide additional information where requested. Please provide ALL requested information as this is one of the most important sections for reporting to the USDOT. ***ONLY provide information relevant to this reporting period.***

Use the table below to complete information about conference sessions, workshops, webinars, seminars, or other events you led/attended where you shared findings as a result of the work you conducted on this project:

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

Type	Title	Citation	Event	Location	Date(s)

i.e. Conference, Symposium, DOT/AOT presentation, Seminar, etc.	Presentation Title	Full Citation	Name of event (i.e. TIDC 1st Annual Conference) or who was the presentation given to?		

Use the table below to report any publications, technical reports, peer-reviewed articles, newspaper articles referencing your work, graduate papers, dissertations, etc. written as a result of the work you conducted on this project. Please list only completed items and exclude work in progress.

Table 4: Publications and Submitted 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

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?

   Novel collar vane was implemented during test field program at Hubbell headquarters.

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. Were any industrial contracts awarded base on furthering planned research and development activities as a result of findings from this work? 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.

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:

- Implementation of T-θ curves can help us to predict the CV behavior under torsional loads.

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:

- N/A

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:

- N/A

Participants and Collaborators:

*Use the table below to list **all** individuals (compensated or not) who have worked on the project.*

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members				
Individual Name & Title	**Dates involved**	**Email Address**	**Department**	**Role in Research**
Aaron Gallant	1/13/2021-	aaron.gallant@maine.edu	Civil and Environmental Engineering	PI
Keith Berube	1/13/2021-	keith.berube@maine.edu	Mechanical Engineering	Co-PI
Aaron Bradshaw	1/13/2021-	abrads@uri.edu	Civil Engineering	Co-PI

*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**
Sebastian Carvajal	1/13/2021		Dr. Aaron Gallant		Master's	Civil Engineering	TIDC University of Maine	Student research assistant. Performing field testing and developing p-y model.

Use the table below to list any students who worked on this project and graduated or received a certificate during this reporting period. Include information about the student's accepted employment (i.e. the student is now working at MaineDOT) or if they are continuing their students through an advanced degree (list the degree and where they are attending).

Table 7: 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?**
			Please list the organization or degree

Use the table below to list any students that participated in Industrial Internships:

Table 8: Industrial Internships			
Student Name	**Degree/Certificate Earned**	**Graduation/Certification Date**	**Did the student enter the transportation field or continue another degree at your university?**
			Please list the organization or degree

*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
Hubbell Power Systems, Inc	Centralia, MO	x	x	x		
Helix Mooring Systems, Inc	Cumberland, ME	x	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
Gary L. Seider, Engineering Manager	glseider@hubbell.com	Hubbell Power System Inc		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

Changes:

List any actual or anticipated problems or delays and actions or plans to resolve them (list no-cost extension requests here)…

List any changes in approach and the reasons for the change…

Planned Activities:

List the activities planned during the next quarter.

- Finishing the implementation of the simplified T-θ curves for all CV geometries and start developing p-y curves to the lateral test results.