**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, Associate 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:** *7/1/2022-9/30/2022*
**Submission Date:** *9/30/2022*

## Overview:

- Finishing Phase I (2021) and executing Phase II (2022) of the Collar Vane (CV) testing plan was carried out in summer 2022 at Hubbell Inc, headquarters in Centralia, MO. Phase II involves the implementation of: a new single-piece CV, perform lateral and torsional test in cohesionless material and, implementation of the CV in square shafts.

- Hubbell Inc. manufactured a single piece (CV) to overcome two-piece CV limitations. This new CV (Fig. 3) is easier to manufacture and install since the bolting along the CV shaft is no longer necessary. Preliminary results indicate benefits of the new CV in torsional tests over the two-piece CV since the transfer-load mechanism is more uniform.

- Lateral response comparison between the two-piece and single-piece vane is shown in Fig 1. Results suggest that the performance of both vanes is the same except for case when CV is D=0.6 m and H=0.9 m where the single piece vane shows a stiffer response. Fig 2. Shows the torsional results and the new vane exceptionally shows a stiffer response and more uniform displacement in the blades.

## Meeting the Overarching Goals of the Project:

- The construction of a Sand Pit to test the CVs in a cohesionless soils was carried out by Hubbell Inc crew. The sand pit dimension was 30x25x8 ft which allowed to perform six monotonic tests. Sand Pit is shown in Fig 4.

- Summer 2022 testing plan includes: Implementation of a single piece collar vane to improve the load transfer mechanism in the torsion test; Construction of a test pit to perform load tests in sandy conditions; implementation of a square shaft HP to demonstrate the versatility of the CV; and cyclic load program.

## Accomplishments:

- The new single-piece collar vane technology overcomes some installation constraints and increased torsional performance since the load transfer mechanism is uniform since the CV is now a single section where all its four blades are connected to the top flange.

- It was proved that the CV can be easily adapted to a square shaft which is more costly effective than the round shaft and preliminary results suggest that performance does not change.

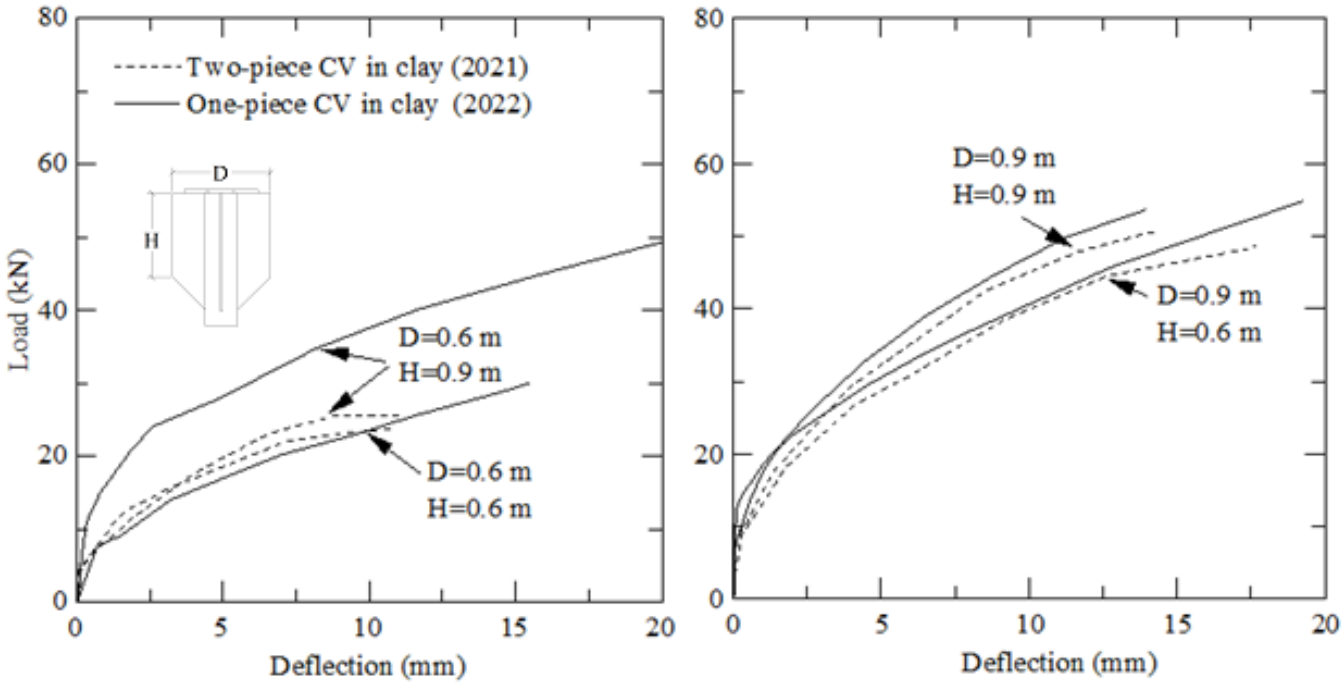
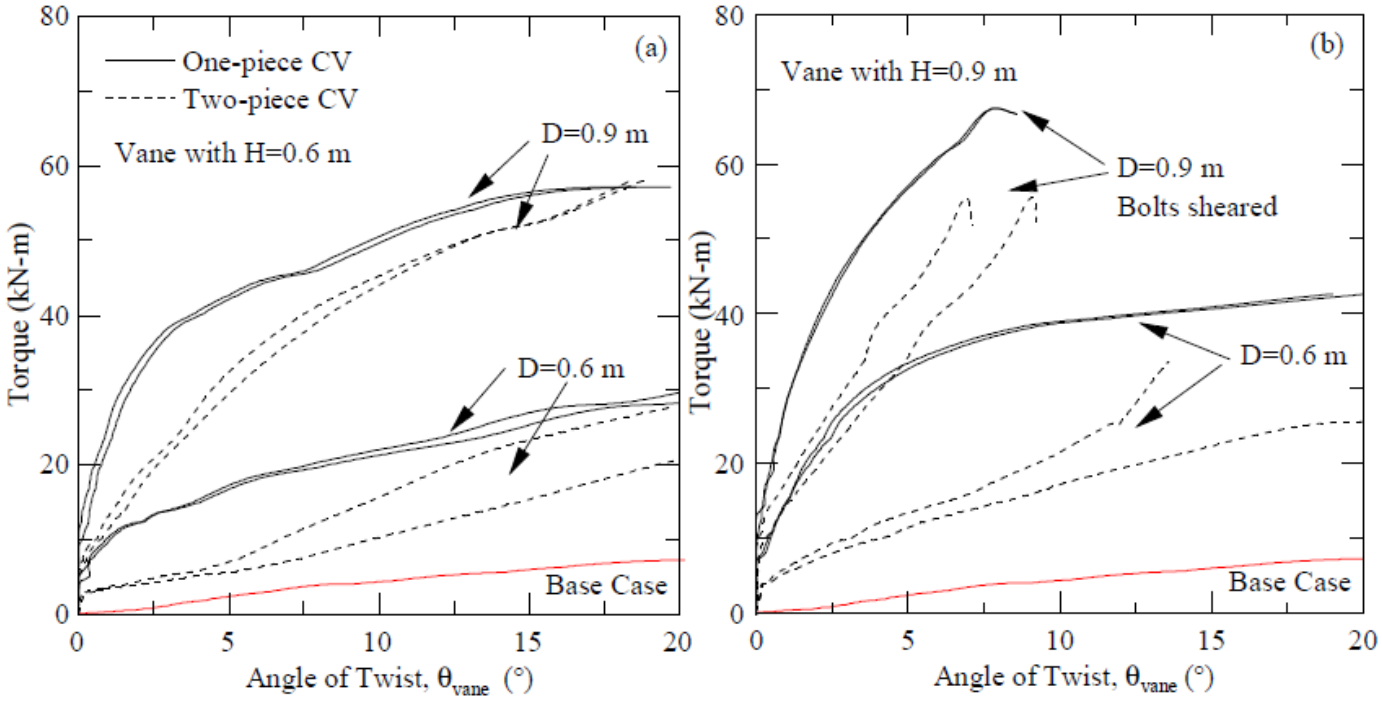



*Figure 1. Lateral response comparison between two-piece and single-piece Collar Vane represented by a dashed and continuous line, respectively. (a) D=0.6m Collar Vane and (b) D=0.9m Collar Vane.*




Note: Two-piece vane (dashed line) shows two different curves for a single CV size due to the not uniformity rotation of the blades.

*Figure 2. Torsion Capacity for different CV sizes. (a) CVs with a height of H=0.6 m. (b) CVs with a height of H=0.9 m.*

**Task, Milestone, and Budget Progress:**

*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 | 100% |
| Task 6: Journal preparation | March 2022 | October 2022 | 80% |
| Task 8: Summer 2022 load tests | July 2022 | August 2022 | 100% |
| Task 9: Numerical analysis | August 2022 | January 2023 | 20% |

| Table 2: Milestone Progress | | | |
|---|---|---|---|
| **Milestone #: Description** | **Corresponding Deliverable** | **Start Date** | **End Date** |
| Milestone 1: | | | |
| Milestone 2: | | | |
| Milestone 3: | | | |
| Milestone 4: | | | |
| Milestone 5: | | | |
| Milestone 6: | | | |
| Milestone 7: | | | |
| Milestone 8: | | | |
| etc. | | | |

| Table 3: 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.)*

**Education and Workforce Development:**

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.)
   *N/A*

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.)
   *N/A*

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 8$^{th}$ 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.)
   *N/A*

**Technology Transfer:**

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

| Type | Title | Citation | Event & Intended Audience | Location | Date(s) |
|---|---|---|---|---|---|
| 2021 Student Poster Contest | Lateral and Torsional Resistance of Modified Helical Piles Using a Novel Collar Vane | Carvajal-Munoz, J. S., Gallant, A., Bradshaw, A., Berube, K. | 2021 Annual TIDC Student Poster Contest | Virtual | December 1, 2021. |

| Table 5: Submitted/Accepted Publications, Technical Reports, Theses, Dissertations, Papers, and Reports | | | | |
|---|---|---|---|---|
| **Type** | **Title** | **Citation** | **Date** | **Status** |
| Peer-reviewed journal: Journal of Geotechnical and Geoenvironmental Engineering | Enhanced lateral and torsional resistance of helical piles augmented with a Collar Vane | Gallant, A., Bradshaw, A., Berube, K. Carvajal-Munoz, J. S. | | In progress |

*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?

   The technology is currently being developed for adoption by Hubbell Power Systems to augment their existing helical piles.

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.

   A patent application has been submitted.

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).

   Hubbell Power systems has provided substantial cost-share towards the project. Helix Mooring has also provided cash support.

*Figure 3. Single-piece collar vane implemented in summer 2022 testing plan. (a) Collar Vane installation. (b) Detailed top flange where all the 4 blades are connected to it.*

*Figure 4. 30x25x8 ft Sand Pit construction sequence. Sand was compacted every foot intended to increase density and strength.*

**Outputs:**

- Single Piece Collar Vane overcomes the limitation of a not uniform load transfer since now the four blades are connected to top flange and results shows that they are deflecting at the same rate.
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**Outcomes:**

- N/A

**Impacts:**

- N/A

**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 |
|---|---|---|---|---|
| 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 |

**Table 7: 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. |

| 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?** |
| N/A | | | |

| 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?** |
| N/A | | | |

| 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** |
| Hubbell Power Systems, Inc | Centralia, MO | x | x | x | | |
| Helix Mooring Systems, Inc | Cumberland, ME | x | x | | | |

| Table 11: Other Collaborators | | | | |
|---|---|---|---|---|
| **Collaborator Name and Title** | **Contact Information** | **Organization and Department** | **Date(s) Involved** | **Contribution to Research** |
| Gary L. Seider, Engineering Manager | | Hubbell Power System Inc | | Technical champion |

| Table 12: Course List | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Level** | **University** | **Professor** | **Semester** | **# of Students** |
| i.e. CE 123 | | Grad or undergrad? | Where was the course taught? | Who taught the course? | Enter Spring, Fall, Summer, Winter and the year | How many students were enrolled in the class? |
| N/A | | | | | | |

**Changes:**

N/A

**Planned Activities:**

- Journal manuscript for a submission on ASCE's Journal of Environmental Engineering is in progress.
- Interpretation of cohesionless soil results and cyclic loads.
- Starting simplified numerical analysis.