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: *4/1/2022-6/30/2022*
Submission Date: *6/30/2022*

Overview:

- Collar Vane (CV) increases the lateral capacity of the Helical Pile (HP) relative to a HP with no collar vane (Fig. 1b). The collar vane also significantly increases the torsional resistance (Fig. 2).

- Using the strain gauges measurements, it is found that the moment is reduced approximately 65 times (Fig. 3a). The unique load transfer mechanism, whereby the geotechnical resistance mobilized by the vane (V_v) is carried back up to the top of the vane and transferred through a flange located near the pile head. The CV is responsible for mobilizing more than 90% of all the subjected lateral force (P) applied for the test shown in Fig. 3b.

- Hubbell crew, PI and Co-PI fixed a proposal test plan for this summer (starting 7/18 to 8/26) to complete the load test matrix.

Meeting the Overarching Goals of the Project:

- Data measured through strain gauges help us to interpret the load transfer mechanism during the lateral load test: It is found that the linearly increasing bending moment is the typical response for all the HP tested with different CVs.

- 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:

- Considering the applied force (P), the shear in the HP (V) using the data from strain gauges at different locations, it was possible to compute the vane resistance (V_V) as shown in Fig 3(b). CV takes between the 80 and 90% of the applied load.

- It was found that, when the HP is subjected to loads, the CV transfer the load to the HP through the flanges where the CV and the HP are connected through bolts.

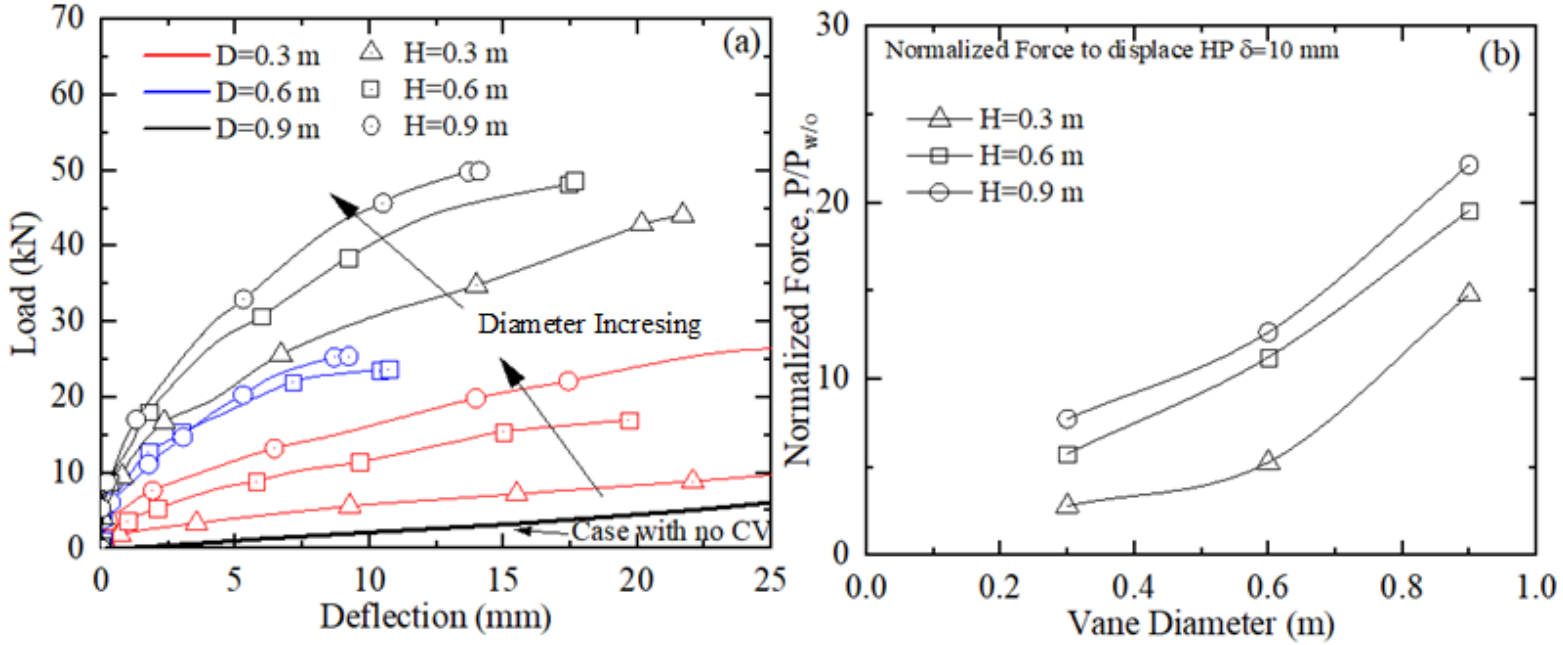

Figure 1. Lateral load results: (a) Load vs deflection curves for different collar vane sizes (b) Normalized load with the case with no Collar Vane required to displace the pile head 10 mm.

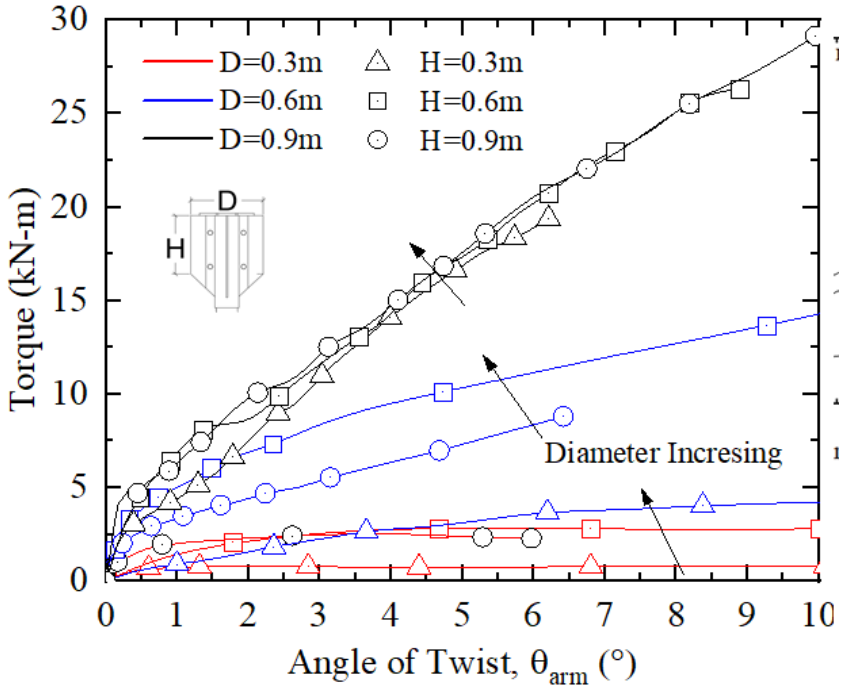

Figure 2. Torsion Capacity for different CV sizes. Angle of twist was measured in the moment arm.

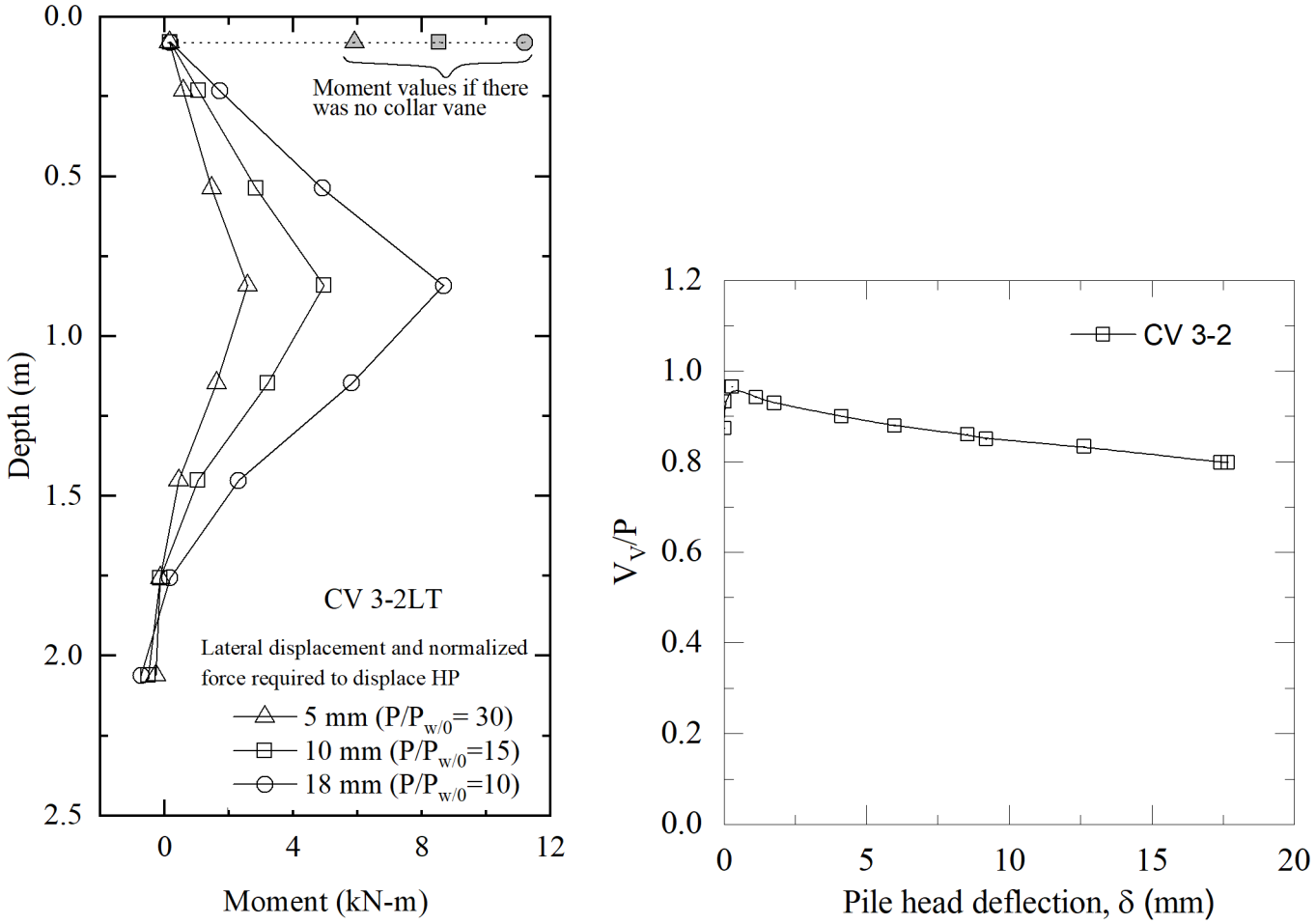

Figure 3. (a) Bending profile showing the values that HP would have if there was no collar vane. (b) Normalized Vane Resistance

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	80%
Task 6: Journal preparation	March 2022	August 2022	60%
Task 8: Summer 2022 load tests	July 2022	August 2022	0%
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 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.)
   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?
   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. 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).
   N/A

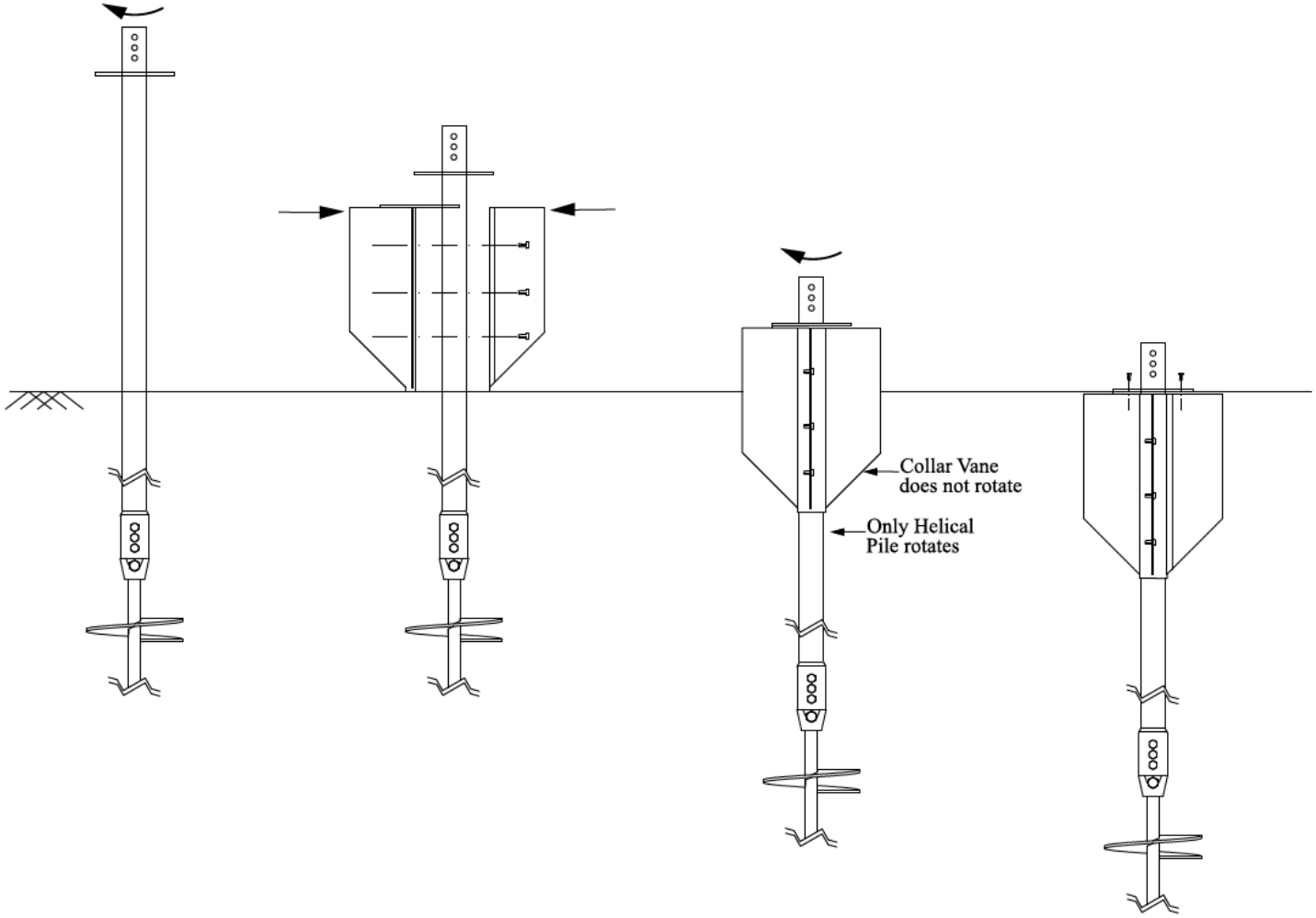

Figure 4. Collar Vane installation. (a)Helical Pile is installed by applying a mechanical torque and a crowd by a drive head. (b) Collar Vane is attached to the Helical pile bolting the two Collar Vane elements along the shaft. (c) Torque is applied to the Helical

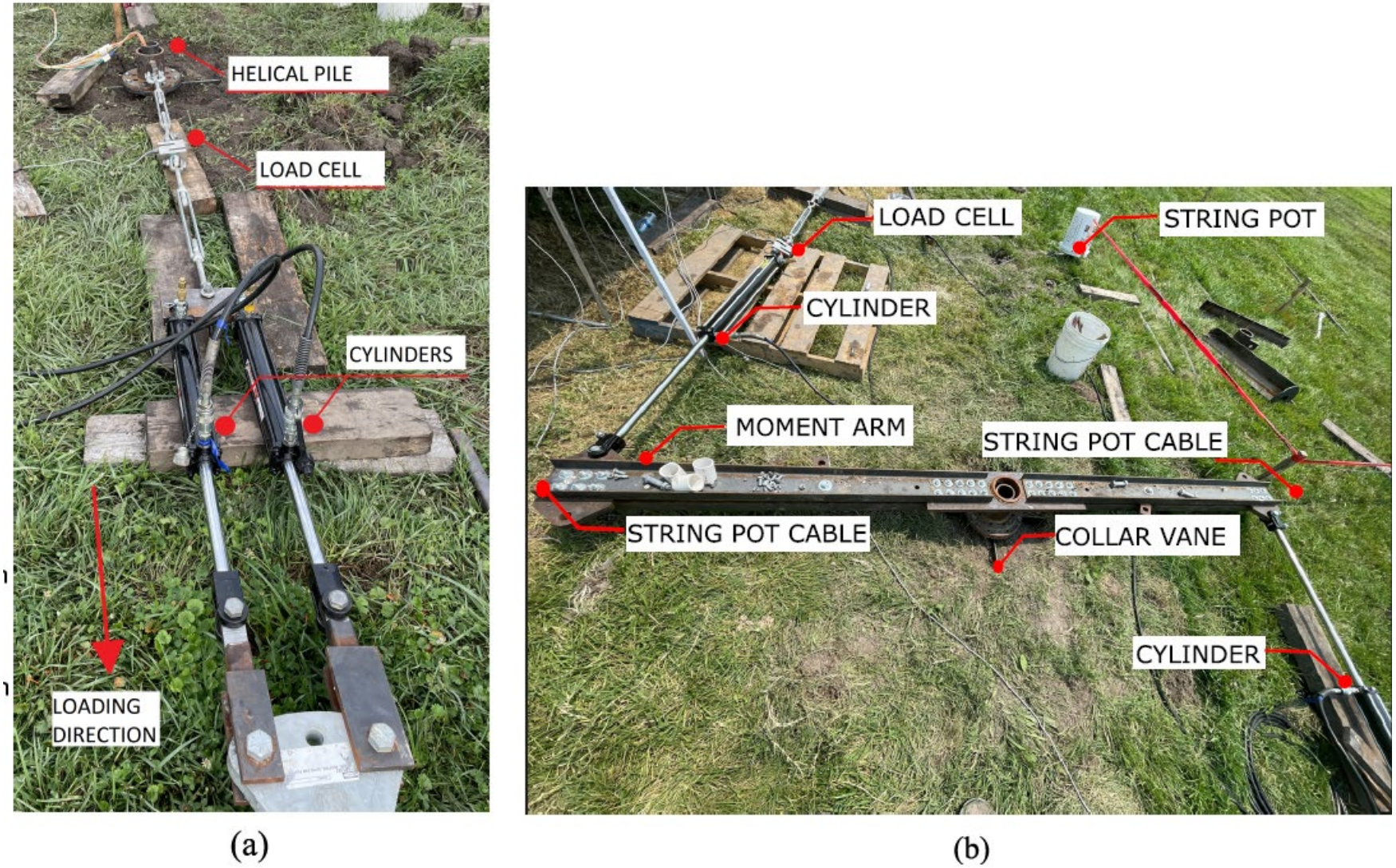

Figure 5. Test frame implemented to apply (a) lateral load (b) torsional loads.

Figure 6. CV 36-36 before installation in the ground. (Vane diameter= 0.9, Total Height = 1.2 m)

Outputs:

- Collar Vane effectively increases the lateral and torsional capacity of the HP. CV takes almost all the external load and transfer the load through the top flange to the HP.

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:

- Paper manuscript for a submission on ASCE's Journal of Environmental Engineering is in progress.
- Perform summer 2022 testing plan to complete testing matrix.