WYOMING DEPARTMENT OF TRANSPORTATION

PROGRESS REPORT

Project title: Comprehensive Field Load Test and Geotechnical Investigation Program for Development of LRFD Recommendations of Driven Piles on Intermediate GeoMaterials

Project Number: RS05219 (TPF 5-391)

Progress period: October 1st, 2022 to December 31st, 2022

Principal Investigator and all others who have worked on the project: Kam Ng (0000-0001-5099-5454); Shaun S. Wulff (0000-0002-5695-4925); Rasika Rajapakshage (postdoc); Nafis Masud (PhD student); Opeyemi Oluwatuyi (PhD student); Lokendra Khatri (MS student-Graduated), Harish Kalauni (MS student-graduated), Carmen Elliott (MS student-graduated), Shafiqul Islam (MS student-graduated); Rebecca Holt (MS student-graduated), Tyler Johnson (MS student-graduated), and Chooi Kim Lau (Undergraduate student-graduated)

1. Please state whether the project is ahead of schedule, on time, or behind schedule: On time.

2. Percentage of overall work completed: 75.19%.

3. Activities and Accomplishments: The information provided in this section allows WYDOT to assess whether satisfactory progress has been made during the reporting period. Please be as detailed as possible, but try to keep your report to three to four pages in length, if possible.

   a. What are the major goals and objectives of the project?

   The overall goal of the research project is to develop LRFD recommendations for driven piles on IGMs. The research objectives are (1) determine representative engineering properties of soil and IGM; (2) evaluate the variability of soil and IGM properties; (3) recommend best geotechnical investigation practices for IGM; (4) develop advanced static analysis methods for pile resistance estimation on IGM; (5) validate and improve the accuracy of dynamic analysis methods; (6) investigate pile setup and/or relaxation; (7) develop LRFD resistance factors for piles on IGM; and (8) recommend changes and improvements to current pile design and construction practices. The research plan has two phases (I and II) and total 14 tasks. Their proposed completion dates, scheduled percent completion and actual percent completion are summarized in the following table.

Task	Description	Proposed Completion Date	Scheduled Percent Completion	Actual Percent Completion
I-1	Historical Pile Data Collection	31-Dec-19	100.00%	100.00%
I-2	Expand Electronic Database	31-Dec-22	100.00%	95.00%
I-3	Identify Bridge Projects for Field Test	31-Dec-19	100.00%	100.00%
I-4	Detailed Geotechnical Investigation	31-Dec-20	100.00%	100.00%
I-5	Innovative Static Load Tests	30-Jun-21	100.00%	72.73%
I-6	Reporting for Phase I	31-Dec-23	0.00%	0.00%
II-1	Geotechnical and Pile Data Interpretation	31-Dec-20	100.00%	100.00%
II-2	Pile Resistance Estimation	30-Jun-22	100.00%	100.00%
II-3	Pile Setup/Relaxation Investigation	30-Sep-22	100.00%	100.00%
II-4	Variability Analysis	31-Dec-22	100.00%	90.00%
II-5	Development of LRFD Resistance Factors	31-Mar-23	67.03%	90.00%
II-6	Cost-Benefit Analysis	30-Jun-23	46.43%	55.00%
II-7	Outcomes and Recommendations	30-Sep-23	21.15%	50.00%
II-8	Reporting for Phase II	31-Dec-23	0.00%	0.00%
Average Percent Completion			73.90%	75.19%

b. Describe what was accomplished under these goals.

1. Major activities.

Agency	Major Activities by Research Team
WYDOT	• Developed an electronic database. • Conducted combined geological uncertainty and inherent variability analysis on all bridge projects used for this study. • Completed triaxial tests on IGM samples from Lodgepole Creek and I-80 Interchange Road projects. • Completed the static pile load test for the Lodgepole Creek and I-80 Interchange Road bridge projects. • Conducted a finite element analysis to simulate the pile load test of the Lodgepole Creek bridge project. • Conducted regression analysis to develop static analysis methods and LRFD resistance factors for piles in IGMs.
IADOT	• Developed an electronic database. • Completed pile load tests for Wapello and Adair bridge projects. • Evaluated and applied six PDA/CAPWAP test results from six bridge projects. • Conducted combined geological uncertainty and inherent variability analysis of Wapello project. • Conducted a finite element analysis to simulate the pile load test of the Adair County bridge project.
CDOT	• Developed an electronic database. • Evaluated historical test pile reports and reported missing information. • Identified four bridge projects for pile load testing. • Conducted triaxial rock tests for the I-05-VA project, the York bridge project and I-70 over Harlan Street project.

	• Prepared a guidance for dynamic testing. • Completed pile load test on the test pile at abutment 4 of the I-05v bridge project, Delta, CO. • Completed pile load test at the E-17-GX bridge project, Denver, CO. • Pile load test is being conducted at the J-17-XA bridge project, Colorado Spring, CO. • Conducted pile sensor installation for the I-70 bridge replacement over Harlan Street, Jefferson and Denver Counties, CO.
KDOT	• Evaluated historical pile data. • Developed electronic database. • Completed historical pile data interpretation. • Developed static analysis methods for piles in shale. • Performed wave equation analysis program on historical test pile data. • Completed the calibration of LRFD resistance factors for piles in shales. • Identified two sites and estimated pile resistances for field pile load tests. • Participated in the project meetings to clarify static load test details for the bidding document preparation.
ITD	• Evaluated historical pile data. • Developed an electronic database. • Completed historical pile data interpretation. • Conducted regression analysis to develop static analysis methods and LRFD resistance factors for piles in IGMs.
MDT	• Developed an electronic database • Received and evaluated historical pile data from MDT. • Conducted geotechnical and pile data interpretation. • Conducted regression analysis to develop static analysis methods and LRFD resistance factors for piles in IGMs.
NDDOT	• Collected and evaluated historical pile data. • Completed triaxial tests on IGM samples from the Cherry Creek bridge site. • Conducted regression analysis to develop static analysis methods and LRFD resistance factors for piles in IGMs. • Completed pile load test for the Cherry Creek bridge project. • Developed an electronic database.
University of Wyoming	• The research team conducted the fifteenth TAC conference meeting on December 13th, 2022. • Five journal manuscripts have been published. • Six journal manuscripts are currently under review. • Five journal manuscripts are currently prepared for submissions. • Three papers are published in the ASCE Geocongress 2022 proceedings. • The research team won the Deep Foundation Institute (DFI) student paper competition award-runner up. • Our paper was presented at the TRB2022 annual meeting. • Two papers accepted for presentation at the TRB 2023 annual meeting. • Kam Ng presented the research outcomes in the web seminar organized by

	the ASCE Geo-Institute on December 7th, 2021. • Kam Ng presented the state-of-practice lecture on driven piles in soft rocks at the 2022 ASCE Geocongress conference. • A provisional patent titled "Geostatistical method for optimizing site investigation to improve pile design and construction" was submitted.

2. Specific objectives. Too early to report.
3. Significant results (both positive and negative). Too early to report.
4. Key outcomes and other achievements. Too early to report.
5. Goals not met. Not applicable.

c. What opportunities for training and professional development has the project provided? Nothing to Report.

d. How have the results been disseminated to communities of interest?
Five journal manuscripts have been accepted and published, and six journal manuscripts are under review. We are preparing five journal manuscripts. Two 2023 TRB papers are accepted for presentation. Furthermore, three papers were presented at the 2022 ASCE Geocongress conference and published in the proceedings. Our paper won the Deep Foundation Institute (DFI) student paper competition award-runner up. Our paper was presented at the TRB 2022 annual meeting. A presentation was given by Kam Ng in the web seminar organized by the ASCE Geo-Institute on December 7th, 2021. A state-of-the practice lecture on driven piles in soft rocks was presented by Kam Ng at the ASCE 2022 Geocongress conference.

e. What do you plan to do during the next reporting period to accomplish the goals and objectives? The research team will conduct the following works:

- Complete the remaining pile load tests in Colorado.
- Start the pile load testing in Kansas.
- Finish incorporating geological uncertainty and inherent variability into LRFD calibration.
- Continue working on the cost-benefit analysis.
- Perform detailed analysis of static pile load test results.

f. List any products resulting from the project during the reporting period. Include in this list:

1. Publications, conference papers, and presentations. In progress.
2. Website(s) or other internet sites (List the URL). Too early to report.
3. Technologies or techniques. Too early to report.
4. Inventions, patent applications, and/or licenses. Too early to report.
5. Other products. Too early to report.

g. Impact:

1. How will this project impact WYDOT? Too early to report.

2. How will this project impact other agencies? Too early to report.

h. Changes to Scope of Work. Provide the following changes, if applicable:

1. Scope of work or objectives of the project. No change.
2. Changes in key persons. No change.
3. Disengagement from the project for more than three (3) months, or a twenty five (25) percent reduction in time devoted to the project. Not applicable.
4. The inclusion of costs that require prior approval. Not applicable.
5. The transfer of funds between line items in the budget. Not applicable.
6. The subawarding, transferring or contracting of work. No change.
7. Changes in the approved cost-sharing or match. Not applicable.