

# 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:** July 1<sup>st</sup>, 2024 to September 30<sup>th</sup>, 2024

**Principal Investigator and all others who have worked on the project (provide name and ORCID number):** Kam Ng (0000-0001-5099-5454); Shaun S. Wulff (0000-0002-5695-4925); Rasika Rajapakshage (postdoc); Nafis Masud (PhD student); Opeyemi Oluwatuyi (PhD student-Graduated); 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. 91.15%
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-23	100.00%	100.00%
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	31-Dec-23	100.00%	100.00%
I-6	Reporting for Phase I	31-Mar-25	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-23	100.00%	100.00%
II-4	Variability Analysis	31-Dec-23	100.00%	100.00%
II-5	LRFD Resistance Factors	31-Mar-24	100.00%	100.00%
II-6	Cost-Benefit Analysis	30-Jun-24	100.00%	100.00%
II-7	Outcomes and Recommendations	30-Sep-24	100.00%	100.00%
II-8	Reporting for Phase II	31-Mar-25	76.16%	75.00%
Average Percent Completion			91.15%	91.07%

b. Describe what was accomplished under these goals.

1. Major activities.

Agency	Major Activities by Research Team
WYDOT	<ul style="list-style-type: none"> <li>Completed triaxial tests on IGM samples from Lodgepole Creek and I-80 Interchange Road projects.</li> <li>Completed the static pile load test for the Lodgepole Creek and I-80 Interchange Road bridge projects.</li> <li>Conducted a finite element analysis to simulate the pile load test of the Lodgepole Creek bridge project.</li> </ul>
IADOT	<ul style="list-style-type: none"> <li>Completed pile load tests for Wapello and Adair bridge projects.</li> <li>Evaluated and applied six PDA/CAPWAP test results from six bridge projects.</li> <li>Conducted combined geological uncertainty and inherent variability analysis of Wapello project.</li> <li>Conducted a finite element analysis to simulate the pile load test of the Adair County bridge project.</li> </ul>
CDOT	<ul style="list-style-type: none"> <li>Identified four bridge projects for pile load testing.</li> <li>Conducted triaxial rock tests for the I-05-VA project, the York bridge project and I-70 over Harlan Street project.</li> <li>Completed pile load test on the test pile at abutment 4 of the I-05v bridge project, Delta, CO.</li> <li>Completed pile load test at the E-17-GX bridge project, Denver, CO.</li> <li>Completed pile load test at the I-70 bridge replacement over Harlan Street, Jefferson and Denver Counties, CO.</li> <li>Completed pile load test at the J-17-XA bridge project, Colorado Spring, CO.</li> </ul>
KDOT	<ul style="list-style-type: none"> <li>Developed static analysis methods for piles in shale.</li> <li>Completed the calibration of LRFD resistance factors for piles in shales.</li> <li>Completed a field pile load test at the K-55 Bridge project, Sumner County, Kansas.</li> <li>Participated in the project meetings to clarify static load test details for the bidding document preparation.</li> <li>Completed a field pile load test at the 235-87 KA Bridge project, Sedgwick County, Kansas.</li> </ul>
ITD	<ul style="list-style-type: none"> <li>Completed historical pile data interpretation.</li> </ul>
MDT	<ul style="list-style-type: none"> <li>Received and evaluated historical pile data from MDT.</li> </ul>

	<ul style="list-style-type: none"> <li>• Conducted geotechnical and pile data interpretation.</li> </ul>
NDDOT	<ul style="list-style-type: none"> <li>• Completed triaxial tests on IGM samples from the Cherry Creek bridge site.</li> <li>• Completed pile load test for the Cherry Creek bridge project.</li> </ul>
University of Wyoming	<ul style="list-style-type: none"> <li>• Developed an electronic database.</li> <li>• Conducted combined geological uncertainty and inherent variability analysis.</li> <li>• Conducted regression analysis to develop static analysis methods and LRFD resistance factors for piles in IGMs.</li> <li>• The research team conducted the 16<sup>th</sup> TAC conference meeting on August 7<sup>th</sup>, 2023.</li> <li>• Nineteen journal manuscripts have been either accepted or published.</li> <li>• Four journal manuscripts are currently prepared for submissions.</li> <li>• One paper was presented at the TRB 2022 annual meeting.</li> <li>• Two papers were presented at the TRB 2023 annual meeting.</li> <li>• One paper was presented at the TRB 2024 annual meeting.</li> <li>• Three papers are published in the ASCE Geocongress 2022 proceedings.</li> <li>• The research team won the Deep Foundation Institute (DFI) student paper competition award-runner up.</li> <li>• Kam Ng presented the research outcomes in the web seminar organized by the ASCE Geo-Institute on December 7<sup>th</sup>, 2021.</li> <li>• Kam Ng presented the state-of-practice lecture on driven piles in soft rocks at the 2022 ASCE Geocongress conference.</li> <li>• A provisional patent titled "Geostatistical method for optimizing site investigation to improve pile design and construction" was submitted.</li> <li>• Kam Ng presented the research outcomes at the 48<sup>th</sup> Deep Foundation Institute Conference on November 2<sup>nd</sup>, 2023.</li> <li>• Kam Ng presented the research outcomes at the 2024 GeoOmaha conference on February 8, 2024.</li> <li>• Research team will present a paper for the 40<sup>th</sup> Rocky Mountain Geo Conference.</li> <li>• Kam Ng presented a paper for the 73<sup>th</sup> Highway Geology Symposium.</li> <li>• Kam Ng will present at the Laramie Engineers Club on October 18, 2024.</li> <li>• Research team is preparing a final report.</li> </ul>

2. Specific objectives. Too early to report.
3. Significant results (both positive and negative). Significant results have been reported in published journals and conference proceedings. They will be highlighted in our final report.
4. Key outcomes and other achievements. The outcomes and achievements have been presented in journals and conferences as summarized in Section 3.b.1.
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?  
Please refer to Section 3.b.1.

e. What do you plan to do during the next reporting period to accomplish the goals and objectives?

- Prepare a final report.

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

1. Publications, conference papers, and presentations. Refer to Section 3.b.1.
  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. One provisional patent was filed.
  5. Other products, such as data or databases, physical collections, audio or video products, software or NetWare, models, educational aids or curricula, instruments or equipment. 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. Not applicable.
  7. Changes in the approved cost-sharing or match. Not applicable.
4. Generative Artificial Intelligence (AI) Tools
- For all Generative AI Tools used in this project set out the following:
- a. List the language models you are using for this project, including which model are used and for what purpose. Please use the methods or acknowledgements section, as appropriate. Not applicable.
  - b. Provide a list of sources used to generate content and citations, including those generated by language models. Double-check citations to ensure they are accurate and properly referenced. Not applicable.
  - c. Be conscious of the potential for plagiarism where the LLM may have reproduced substantial text from other sources. Check the original sources to be sure you are not plagiarizing someone else's work. Not applicable.

**NOTE:** Authors who use AI tools in the writing of a manuscript, production of images or graphical elements of any report, or in the collection and analysis of data, must be transparent in disclosing in the Materials and Methods (or similar section) of the report how the AI tool was used. Authors are fully responsible for the content of their manuscript, even those parts produced by an AI tool, and are thus liable for any breach of publication ethics. AI bots, such as ChatGPT should not be listed as an author on your submission of your final report or any derivative reports using the research from this project.