**TRANSPORTATION POOLED FUND PROGRAM**

**QUARTERLY PROGRESS REPORT**

**Lead Agency: Utah Department of Transportation**

**INSTRUCTIONS:**

*Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.*

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| **Transportation Pooled Fund Program Project #**  **TPF-5(381)** | | **Transportation Pooled Fund Program - Report Period:**  \_ Quarter 1 (January 1 – March 31, 2019)  **x Quarter 2 (April 1 – June 30, 2019)**  \_ Quarter 3 (July 1 – September 30, 2019)  \_ Quarter 4 (October 1 – December 31, 2019) | |
| **Project Title:**  Evaluation of Lateral Pile Resistance Near MSE Walls at a Dedicated Wall Site – Phase 2 | | | |
| **Name of Project Manager(s):**  David Stevens | **Phone Number:**  801-589-8340 | | **E-Mail**  [davidstevens@utah.gov](mailto:davidstevens@utah.gov) |
| **Lead Agency Project ID:**  FINET 42085, ePM PIN 16761  UDOT PIC No. UT17.404 | **Other Project ID (i.e., contract #):**  UDOT Contract No. 19-8182 | | **Project Start Date:**  August 20, 2018 |
| **Original Project End Date:**  September 30, 2020 | **Current Project End Date:**  September 30, 2020 | | **Number of Extensions:**  1 |

Project schedule status:

**X** On schedule \_ On revised schedule \_ Ahead of schedule \_ Behind schedule

Overall Project Statistics:

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| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work**  **Completed to Date** |
| $220,000.00 (current contract)  $240,000.00 (total commitments) | $60,000.00 | 30% |

***Quarterly*** Project Statistics:

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| **Total Project Expenses**  **and Percentage This Quarter** | **Total Amount of Funds**  **Expended This Quarter** | **Total Percentage of**  **Time Used to Date** |
| 0% | $0.00 | 42% |

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| **Project Description**:  Bridge abutment piles are frequently surrounded by mechanically stabilized earth (MSE) walls rather than a soil slope. Piles near MSE walls must be designed for lateral loads from earthquakes and thermal expansion/contraction. In the TPF-5(272) Phase 1 study involving several state DOTs, a series of 31 tests on free-head piles provided p-multipliers as a function of pile spacing which can be used to account for reduced lateral soil resistance due to the presence of an MSE wall. Equations were also developed to compute the induced force developed in the reinforcements by the lateral pile loading. However, a number of questions came up when the results of the Phase 1 study were presented to engineers and those responsible for code changes. These issues involve (a) the effect of cyclic loading when previous testing was monotonic, (b) the effect of pile head fixity because previous tests were on free-head piles while most abutment piles are “fixed-head”, (c) the effect of pile group loading when previous tests were for single piles, and (d) the effect of pile diameter on the p-multiplier and induced force equations because previous tests were all for piles about 12 inches in diameter.  Objective: To provide closure relative to the outstanding issues described above, a series of additional tests will be conducted as a Phase 2 follow-up to the original test series.  The Phase 1 study included construction of a dedicated MSE wall site in Utah with instrumented piles behind the 20-ft high wall.  Tasks for this Phase 2 study include:  1. Excavate the top 6 ft of the soil backfill behind the existing MSE wall.  2. Instrument MSE reinforcements and piles with strain gauges.  3. Re-compact the top 6 ft of the soil backfill behind the existing MSE wall.  4. Conduct cyclic lateral pile load testing.  5. Conduct fixed-head lateral pile load testing.  6. Conduct lateral pile load testing of larger-diameter piles (24-inch diameter), to be newly placed between cut-off existing piles.  7. Conduct lateral pile load testing of a pile group.  8. Develop p-multipliers for Phase 2 lateral pile load testing results, compare these with the Phase 1 results, and update the overall p-multiplier equation as necessary.  9. Develop tensile force equations for Phase 2 lateral pile load testing results, compare these with the Phase 1 results, and update the overall tensile force equations as necessary.  10. Submit a final report that documents the Phase 2 research effort.  11. Report results to TAC committee members in video conferences.  12. Make presentations at AASHTO bridge engineers’ committee meetings and TRB events to aid in national efforts to implement the study results.  Dr. Kyle Rollins of BYU is the Principal Investigator for this research project. The technical advisory committee (TAC) for the study currently includes representatives from UT, CA, FL, KS, MN, NY, and WI state DOTs. |

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| **Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):**  **Task 1** – Completed.  **Task 2** – Completed.  **Task 3** – Completed.  **Task 4** – Started memo reporting on this completed testing.  **Task 5** – Started memo reporting on this completed testing.  **Task 6** – Started memo reporting on this completed testing.  **Task 7** – Started memo reporting on this completed testing.  **Task 8** – Started this task.  **Task 9** – Not started.  **Task 10** – Not started.  **Task 11** – Not started.  **Task 12** – Not started.  **Contract** – No changes this quarter. |
| **Anticipated work next quarter**:  **Task 1** – Completed.  **Task 2** – Completed.  **Task 3** – Completed.  **Task 4** – Submit the task completion memo with test layout, procedure, basic results, and load-deflection curves.  **Task 5** – Submit the task completion memo with test layout, procedure, basic results, and load-deflection curves.  **Task 6** – Submit the task completion memo with test layout, procedure, basic results, and load-deflection curves.  **Task 7** – Submit the task completion memo with test layout, procedure, basic results, and load-deflection curves.  **Task 8** – Develop p-multipliers for Phase 2 lateral pile load testing results, and submit the task completion memo.  **Task 9** – Start developing reinforcement tensile force equations.  **Task 10** – None planned.  **Task 11** – Hold a TAC web conference to provide updates and discuss progress.  **Task 12** – None planned.  **Contract** – Consider adding the remaining pooled fund commitment amount to the contract for face-to-face TAC meetings or additional numerical analysis and pressure cell analysis. |

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| **Significant Results:**  As the data reduction efforts have progressed, we have started to calibrate the measured pile head load-deflection curves with curves computed using LPILE so that p-multipliers can be obtained. First, the computed load-deflection curves were calibrated with the measured curve for the pile located 5 diameters (5D) behind the wall (distance from center of pile to the back face of the wall). These calibrated soil properties were then kept constant in computing the load-deflection curves for the piles located at other distances behind the wall (4D, 3D, and 2D). Agreement with measured curves was then obtained by using a single p-multiplier for the entire length of the pile for each pile spacing. The p-multiplier reduces the soil resistance against the pile to account for the presence of the MSE wall face. Fig. 1 compares the computed and measured load-deflection curves for the 2 ft. diameter pipe pile located 5D behind the wall and the agreement is reasonably good. The computed and measured load deflection curves for the other piles at 4D, 3D and 2D are also shown in Fig. 1 along with the p-multiplier required to obtain the best agreement (see legend). Using the relatively simple p-multiplier approach, very god agreement was obtained for the other pile spacings. Back-calculated p-multipliers for the pile located 5D, 4D, 3D, and 2D behind the wall were 1.0, 0.90, 0.49 and 0.44, respectively.  Fig. 2 provides a plot of the p-multipliers back-calculated for the 2 ft. diameter pipe piles as a function of normalized pile spacing behind the MSE wall. Fig. 2 also provides the best-fit design line based on tests with the 1 ft. diameter/width piles along with the back-calculated p-multiplier data points for all previous test results. Generally, the back-calculated p-multipliers for the 2 ft. pipe piles fit well with the previous test results for the 1 ft. diameter/width piles. This is likely a result of the fact that the tensile force developed of the MSE reinforcements was typically much less than the ultimate resistance for the 1 ft diameter pile tests. Nevertheless, the p-multiplier for the pile located 3D behind the MSE wall is somewhat lower than might be expected. This discrepancy is likely associated with the fact that the test on the pile at 2D spacing was performed prior to the test on the pile at 3D spacing. The shear planes fanning out from the edges of the pile for the 3D pile test overlapped with those developed previously for the 2D pile. The overlapping shear zones likely reduced the lateral resistance of the 3D pile in comparison to what might have been developed for a virgin load test. This problem with overlapping shear zones was not significant for the 1 ft. diameter piles because they were spaced at 5D center to center parallel to the wall while the 2 ft. diameter piles were spaced at 2.5D center to center parallel to the wall. It is important to note, however, that the back-calculated p-multiplier for the test on the 2 ft diameter pile located 2D behind the wall was 0.44 relative to the 0.42 predicted by the best-fit curve equation, which represents excellent agreement. In this test, the pile was loaded under virgin conditions with no overlapping shear planes. This excellent agreement suggests that p-multipliers for 2 ft diameter piles can be reasonably estimated using the equations developed for the 1 ft diameter test piles.    Fig. 1 Comparison of measured pile head load-deflection curves and curves computed by LPILE using a constant p-multiplier for each spacing.    **Fig. 2 Comparison of back-calculated p-multipliers (PMSE) for the lateral pile load tests on 2 ft. diameter piles in comparison with back-calculated p-multipliers. The best-fit line from the tests with the 1 ft. diameter piles is also shown for comparison.** |
| **Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that**  **might affect the completion of the project within the time, scope and fiscal constraints set forth in the**  **agreement, along with recommended solutions to those problems).**  None. |

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| **Potential Implementation:** |