**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)  \_ Quarter 2 (April 1 – June 30, 2019)  \_ Quarter 3 (July 1 – September 30, 2019)  **x 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)  $230,000.00 (obligated on PIN) | $120,000.00 | 55% |

***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** |
| 27% | $60,000.00 | 65% |

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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** – Completed.  **Task 5** – Completed.  **Task 6** – Completed.  **Task 7** – Worked on memo reporting on this completed testing.  **Task 8** – Continued this task.  **Task 9** – Worked on data reduction and started analysis.  **Task 10** – Not started.  **Task 11** – Not started.  **Task 12** – Dr. Rollins gave a presentation at an AASHTO bridge engineers committee meeting in Nov. 2019.  **Contract** – No changes this quarter. |
| **Anticipated work next quarter**:  **Task 1** – Completed.  **Task 2** – Completed.  **Task 3** – Completed.  **Task 4** – Completed.  **Task 5** – Completed.  **Task 6** – Completed.  **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** – Continue 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:**  During this quarter, research has focused on developing tensile force vs. length curves for load tests conducted on the fixed-head piles, the 24-inch diameter piles and the three pile group. Tensile force in the reinforcements was computed from strain gauge measurements. To minimize bending effects, strain gauge pairs were bonded to the top and bottom of the 18 foot long reinforcements at distances of 0.5, 2, 3, 5, 8, 11, and 14 feet away from the MSE wall. Typically, reinforcements at three depths were instrumented at two distances transverse to the loaded pile.  Typical results are shown in this report for the ribbed strip reinforcements used to support the wall in-front of the 24-inch pipe piles. The tensile force (T) in kips developed in these reinforcements was calculated using the equation  where  E = the modulus of elasticity of the ribbed strip soil reinforcement (29,000 ksi)  A = the cross-sectional are of the ribbed strip soil reinforcement (0.31 inches2)  µεAVG = the average micro strain on the top and bottom of the reinforcement  In this report, we have plotted tensile force in the reinforcement as a function of distance behind the wall for a number of load increments during the load tests conducted on the piles driven at 6 feet [3 pile diameters (3D)] and 10 feet [5 pile diameters (5D)] from the center of the pile to the back face of the wall. Results are shown for reinforcement depths of 1.25 feet and 3.75 feet below the ground surface.  Figs. 1 and 2 show results for the pile at 3D for reinforcements at 1.25 feet and 3.75 feet, respectively. Figs. 3 and 4 show results for the pile at 5D for reinforcements at 1.25 feet and 3.75 feet, respectively. The results from the load tests are similar to that obtained previously for the 12.75-inch diameter pipe piles. As the lateral pile head load increases, the tensile force in the pile increases. For both the pile at 3D and 5D, the reinforcement tensile force is higher at the 3.75 foot depth than at the 1.25 foot depth. The maximum tensile force typically occurs at or close to the location of the test pile rather than at the wall face. In contrast to previous test, the tensile force in the reinforcements is significantly greater than zero at the wall face particularly for the reinforcements at 1.25 feet. This indicates that the lateral pile load for the 24-inch pipe piles is transmitting load to the wall panel which is then being resisted by the reinforcements. Finally, the maximum tensile reinforcement force is higher for the pile at 3D than for the pile at 5D, which was not consistently observed for the previous tests on 12.75-in piles. The results to date indicate that the vast majority of the lateral pile load was resisted by the reinforcements.  **Fig. 1. Reinforcement tensile force vs. distance behind the MSE wall for a number of pile head loads applied to the 24-inch diameter pile located 6 feet (3D) behind the MSE wall. The reinforcement is located at a depth of 1.25 feet.**  **Fig. 2. Reinforcement tensile force vs. distance behind the MSE wall for a number of pile head loads applied to the 24-inch diameter pile located 6 feet (3D) behind the MSE wall. The reinforcement is located at a depth of 3.75 feet.**  **Fig. 3. Reinforcement tensile force vs. distance behind the MSE wall for a number of pile head loads applied to the 24-inch diameter pile located 10 feet (5D) behind the MSE wall. The reinforcement is located at a depth of 1.25 feet.**    **Fig. 4. Reinforcement tensile force vs. distance behind the MSE wall for a number of pile head loads applied to the 24-inch diameter pile located 10 feet (5D) behind the MSE wall. The reinforcement is located at a depth of 3.75 feet.** |
| **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:** |