**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, 2020)  **x Quarter 2 (April 1 – June 30, 2020)**  \_ Quarter 3 (July 1 – September 30, 2020)  \_ Quarter 4 (October 1 – December 31, 2020) | |
| **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)  $240,000.00 (obligated on PIN) | $140,000.00 | 65% |

***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** |
| 9% | $20,000.00 | 90% |

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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** – Completed. Submitted a preliminary memo on this task.  **Task 8** – Continued this task.  **Task 9** – Continued this task.  **Task 10** – Drafted 3 reports on the 4 pile test groupings.  **Task 11** – Not started.  **Task 12** – Some presentations given already.  **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** – Completed.  **Task 8** – Develop p-multipliers for Phase 2 lateral pile load testing results, and submit the task completion memo.  **Task 9** – Develop reinforcement tensile force equations, and submit the task completion memo.  **Task 10** – Complete 3 draft reports on the 4 pile test groupings and a shorter summary report, and submit these for TAC review.  **Task 11** – Hold a TAC web conference to provide updates and discuss progress.  **Task 12** – None planned.  **Contract** – Add the remaining pooled fund commitment amount to the contract for detailed statistical analysis on Task 9. |

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| **Significant Results:**  This quarter the research team has been summarizing results from the cyclic lateral load tests on the 12.75 inch diameter steel pipe piles Load was applied in 15 sinusoidal cycles towards and away from the MSE wall at progressively higher deflection increments as shown in Fig. 1. As deflection increases, the load-defection curves become more non-linear and exhibit greater hysteretic loops.  **Fig 1. Continuous pile head load vs. pile head displacement curve for pipe pile spaced 3.1D from MSE wall.**  Figs. 2 and 3 compare the load vs. displacement curves towards and away from the wall for cyclically loaded pile spaced at 4.2D and 2.3D behind the MSE wall, respectively. The first several points on each curve represent the accumulation of loading during the first loading cycle of the first displacement increment, while the remainder of the points represents the maximum displacement of the first loading cycle of each displacement increment. For statically loaded piles, spacing from the wall at 3.9 pile diameters or greater generally resulted in no loss of stiffness in the soil-wall system. For pile spacing less than 3.9 pile diameters generally resulted in decreased stiffness of the laterally load piles, and as the spacing decreased, lateral pile stiffness decreased as well.    **Fig. 2. Back-bone pile head load vs. pile head displacement curves for displacement increments towards and away from the MSE wall for the cyclically loaded pipe pile spaced at 4.2D from the wall.**    **Fig. 3 Back-bone pile head load vs. pile head displacement curves for displacement increments towards and away the MSE wall for the cyclically loaded pipe pile spaced at 1.5D from the wall.**  For the cyclically loaded piles at 5.3D and 4.2D spacing behind the wall, there was relatively little difference between the “back-bone” load-deflection curves towards and away from MSE wall as illustrated in Fig. 2. However, as shown in Fig. 3, for the test pile at 1.5D behind the MSE wall, the load-deflection curve towards the wall showed a decrease in lateral resistance when loaded towards the wall compared with loading away from the wall.  Figs. 4 and 5 provides back-bone lateral pile head load-deflection curves for the tests on the piles at spacings of 5.3D, 4.2D, 3.1D behind the MSE wall when loaded towards and away from the wall, respectively. In Fig. 4, there is little reduction in lateral resistance for the test piles spaced less than more than 4D behind the wall, but significant reductions for test piles closer than 4D as expected based on static free-head lateral pile load testing. These results are consistent with observations from static loading. In contrast, the pile head lateral load-deflection curves for load tests away from the wall are all essentially similar because the soil profile is consistent with distance.    **Fig. 4 Back-bone pile head load-defection curves for pipe piles spaced at 5.3D, 4.2D, 3.1D, and 1.5D behind the MSE wall when loaded towards the wall.**  **Fig. 5 Back-bone pile head load-defection curves for pipe piles spaced at 5.3D, 4.2D, 3.1D, and 1.5D behind the MSE wall when loaded away from the wall.**  Fig. 6 shows the average decrease in lateral resistance with the number of load cycles for the test piles spaced at 1.5D, 3.1D, 4.2D and 5.3D towards the wall relative to the load for the first cycle of loading. These tests were performed in a compacted silty sand with gravel. With 15 cycles of loading, typical of a magnitude 7.5 earthquake, there is a reduction in load of about 10 to 15%. There does not appear to be any consistent trend with respect to pile spacing. Fig. 7 shows similar plots for a laterally loaded single pile and pile groups in clay. The results are generally consistent with the results from this study, although the reduction in load is slightly higher for clay (15 to 20%).    **Fig. 6 Reduction in normalized pile head load with number of cycles for test piles spaced at 1.5D, 3.1D, 4.2D and 5.3D with silty sand backfill.**    **Fig. 7 Reduction in normalized pile head stiffness with number of cycles for pile groups in clay reported by Rollins et al. (2006).** |
| **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:** |