**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:** **x Quarter 1 (January 1 – March 31, 2021)** \_ Quarter 2 (April 1 – June 30, 2021)\_ Quarter 3 (July 1 – September 30, 2021)\_ Quarter 4 (October 1 – December 31, 2021) |
| **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 |
| **Lead Agency Project ID:**FINET 42085, ePM PIN 16761UDOT 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:** June 15, 2021 | **Number of Extensions:**2 |

Project schedule status:

 \_ On schedule **X** 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** |
| $240,000.00 (current contract)$240,000.00 (total commitments)$240,000.00 (obligated on PIN) | $185,000.00 | 85% |

***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** |
| 19% | $45,000.00 | 93% |

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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. **Task 8** – Completed.**Task 9** – Previously submitted the first of two task completion memos for Task 9 on reinforcement tensile force equations. This one reports on the original Task 9 scope results. The second Task 9 memo will be submitted subsequently to report on the activity and completion of the additional Task 9 statistical analysis.**Task 10** – The three draft final reports were received previously for TAC review: one each on the “Group Test,” the "Fixed Head Pile Test," and the "Cyclic and 24 Inch Pile Tests.”**Task 11** – No TAC meetings were held this quarter.**Task 12** – Some presentations were given already.**Contract** – No changes were made to the contract this quarter.**State DOTs survey –** Completed previously.  |
| **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** – Completed**Task 9** – Finalize the Task 9 statistical analysis for reinforcement tensile force equations. **Task 10** – Finalize the three final reports based on feedback received from the TAC members on the draft versions. Prepare the shorter summary report addressing all of the key results from the Phase 2 study.**Task 11** – Consider holding a virtual TAC meeting to discuss final results and implementation.**Task 12** – None planned.**Contract** – No changes are planned.**State DOTs survey –** We'll look for a way to incorporate these survey results in the final reports for the current TPF-5(381) study. |

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| **Significant Results:**During the 1st quarter of 2021, we have completed the statistical analysis of tensile force in the ribbed strip reinforcements. Specifically, we have developed a single tensile force equation that can account for both the free-head and fixed-head boundary conditions. For example, we have included the measured maximum reinforcement tensile forces from both the fixed-head and free-head test in a new regression analysis. The input parameters have been normalized so that they are not dependent on the units used. The revised equation for the increased tensile force, ΔF, due to applied pile load near an MSE wall with welded-wire reinforcements is given by$$∆F\left(kips\right)=10\^[17.83\frac{P}{P\_{y}}+0.233\frac{D}{D\_{o}}-3.83x10^{-2}\frac{S}{D}-5.8x10^{-2}\left(\frac{T}{D}\right)-8.22\left(\frac{T}{D}\right)\left(\frac{P}{P\_{y}}\right)-0.12]-1$$ Where:P, is the pile head load in units of forcePy, is the yield force of the pile under compression in units of forceS, is the distance from the back face of the wall to the center of the pile in units of lengthD, is the diameter of the pile in units of length, consistent with S & TDo, is a diameter of 12.75 inch σv, is the vertical stress of the soil at the depth of the reinforcing strip in units of pressurepo, is the atmospheric pressure (a constant value) in units of pressure.T, is the transverse distance from the center of the pile to the center of the reinforcing gridThis equation is based on about 1078 data points and has a correlation coefficient, R2, of about 0.72 and a standard deviation σ = 0.16. If P = 0, then ΔF is assumed to be zero. In addition, ΔF is taken as zero if the computed value is less than 0. This equation is applicable to pile with diameters of 12 to 24 inches and relative compactions from 90 to 95% of the standard Proctor maximum density. A comparison of the log measured to log computed forces is provided in Fig. 1 for all the data points in the dataset. Using this revised equation, the agreement is relatively good for both the previous free-head tests and the new fixed-head tests completed in Phase 2 of this study.Fig. 1. Comparison of log measured to predicted increased tensile force due to applied lateral load on a pile near an MSE wall with ribbed-strip reinforcement.   |
| **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).**Because the field testing is completed, students can complete their analysis work on-line. Therefore the project has not been impeded by COVID 19 restrictions to this point. |

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| **Potential Implementation:**  |