**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(272)** | | **Transportation Pooled Fund Program - Report Period:**  \_ Quarter 1 (January 1 – March 31, 2016)  \_ Quarter 2 (April 1 – June 30, 2016)  X **Quarter 3 (July 1 – September 30, 2016)**  \_ Quarter 4 (October 1 – December 31, 2016) | |
| **Project Title:**  Evaluation of Lateral Pile Resistance Near MSE Walls at a Dedicated Wall Site | | | |
| **Name of Project Manager(s):**  Jason Richins | **Phone Number:**  801-360-4985 | | **E-Mail**  jtrichins@utah.gov |
| **Lead Agency Project ID:**  Finet 42053, ePM PIN 11075  UDOT PIC No. UT11.404 | **Other Project ID (i.e., contract #):**  UDOT Contract No. 148434 | | **Project Start Date:**  December 2, 2013 |
| **Original Project End Date:**  September 30, 2016 | **Current Project End Date:**  September 30, 2016 | | **Number of Extensions:** |

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** |
| $322,000.00 (current contract)  $332,000.00 (total committed online)  $352,000.00 (total actual committed) | $229,500.00 | 71% |

***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% | $0 | 103% |

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| **Project Description**:  Pile foundations for bridges with integral abutments must resist lateral loads produced by earthquakes and thermal expansion or contraction. Increasingly, right-of-way constraints are also leading to vertical mechanically stabilized earth (MSE) walls at abutment faces. Currently, there is relatively little guidance for engineers in assessing the lateral resistance of piles located close to these MSE walls. As a result, some designers assume that the soil provides no resistance whatsoever which leads to larger pile diameters and increased foundation cost. Other designers locate the abutment piles six to eight pile diameters behind a wall face to minimize the interaction and use conventional design approaches. However, this approach increases the bridge span and the cost of the bridge structure. Still other designers position the pile close to the wall face and reduce the lateral pile resistance using engineering judgment. However, the appropriate reduction factor to use as a function of pile spacing is not well defined.  Recent testing conducted by Rollins et al (2013) and Pierson et al (2008) indicate that lateral resistance decreases substantially as pile spacing from the wall decreases; however, reinforcing can reduce this effect. Rollins et al also found that p-multipliers defined as a function normalized spacing and reinforcement length seemed to provide reasonable agreement with measured pile response. Furthermore, Rollins et al found that the tensile force in the reinforcements owing to the lateral load on the pile could be estimated for design purposes using a correlation with pile load, spacing behind the wall, and distance transverse from the pile load.    Although the tests to date provide a framework for understanding the mechanisms involved and likely design approaches, the available data is too limited to make firm design recommendations. To improve our understanding of pile-MSE wall interaction, this project will involve construction of a test embankment approximately 80 ft long and 20 ft tall where it will be possible to conduct a number of lateral pile load tests on different pile types behind an MSE wall with both strip and grid type steel reinforcements. Additional contributions to the project will consist of in-kind donations from various contractors and material suppliers.  Objectives for this study include:  1. Measure reduced lateral pile resistance vs. displacement curves for circular, square, and H piles behind an MSE wall with steel strips and grid reinforcement.  2. Measure the increase and distribution of tensile force in the MSE reinforcement induced by lateral pile loading.  3. Measure effect of special pile head geometry (e.g. corrugated pipe sleeves, double plastic sheeting) on lateral pile resistance.  4. Develop design rules (e.g. p-multipliers) to account for reduced pile resistance as a function of spacing and reinforcement.  5. Develop equation to predict reinforcement force induced by pile loading.  6. Develop design equations to account for pile shape and pile head geometry.  Tasks for this study include:  1. Instrument test piles and reinforcements.  2. Drive test piles and construct MSE wall to height of 15 ft.  3. Perform lateral load tests on piles with 15 ft high MSE wall.  4. Reduce data and develop report on the testing for the 15 ft high wall.  5. Determine p-multipliers and reinforcement force equations for 15 ft high wall test results.  6. Perform lateral load tests on piles with 20 ft high MSE wall.  7. Reduce data and develop report on the testing for the 20 ft high wall.  8. Determine p-multipliers and reinforcement force equations for 20 ft high wall test results.  9. Develop design recommendations to account for pile sleeves and plastic sheeting effects.  10. Prepare final report with recommendations based on all tests.  11. Hold Technical Advisory Committee (TAC) meetings.  12. Present results of the study at AASHTO, TRB, and ASCE meetings.  Dr. Kyle Rollins of BYU is the Principal Investigator for this research project. The technical advisory committee (TAC) includes representatives from UT, FL, IA, KS, MA, MN, MT, NY, OR, TX, and WI DOTs. |

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| **Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):**  Task 1 – 100% complete.  Task 2 – 100% complete.  Task 3 – 100% Complete  Task 4 – 100% Complete  Task 5 – 100% Complete  Task 6 – 100% Complete.  Task 7 – 100% Complete.  Task 8 – 100% Complete.  Task 9 – 100% Complete.  Task 10 – 80% Complete  Task 11 – 100% Complete  Contract – A contract modification was completed to provide funding for all the work tasks. |
| **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 – Completed  Task 10 – Report is in preparation  Task 11 – TAC meeting Completed  Task 12 – Presentation at AASHTO meeting completed  Contract – A contract modification may be prepared for additional work tasks based on available funding. |

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| **Significant Results:**  During the past quarter we have been working to complete two shorter papers; one describing the pile shape effects and one describing the pile-MSE wall interaction. These two papers are nearing completion and will be completed in the next quarter. This effort will complete required work for the current work tasks.  As we prepared the summary paper on pile-MSE wall interaction, we addressed concerns from the TAC and industry sponsors that additional information on wall deflection during load would be helpful. Fig. 1 provides a plot showing the maximum wall displacement obtained from both the digital image correlation (DIC) imaging and the string potentiometers at the top of the wall for a pile head deflection of one inch. Deflections are shown for all pile tests at various normalized distances behind the wall. With a pile head deflection of one inch, the average maximum deflection on the wall was 0.1 inch. The mean plus two standard deviation maximum deflection was 0.25 inch. The peak deflection did not seem to decrease appreciably with increased distance from the wall.  Figure 2 shows similar data for a three inch pile head deflection. In this case the average peak deflection anywhere on the wall was 0.28 inch while the mean plus two standard deviation value was 0.61 inch. Once again the variation with normalized distance behind the wall was relatively small.  Compared to the applied pile head deflection, the peak wall deflections were relatively small in both cases and did not produce significant distress to the wall panels. It should be noted that masonry block reinforcements with geogrid reinforcements displaced two inches when the pile head deflected three inches in tests conducted by the University of Kansas. Therefore, the metallic reinforcements were quite effective in limiting wall deflections for the steel piles in this testing series relative to the geosynthetic reinforcements.    **Fig. 1 Maximum wall displacement measured by DIC and string potentiometers versus normalized pile distance from the wall for a pile head deflection of one inch. Average peak deflection and average plus two standard deviation peak deflections are shown for the entire data set.**    **Fig. 2 Maximum wall displacement measured by DIC and string potentiometers versus normalized pile distance from the wall for a pile head deflection of three inches. Average peak deflection and average plus two standard deviation peak deflections are shown for the entire data set.** |
| **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).**  The project work tasks have nearly been completed within the original time and budget anticipated. Additional work tasks suggested during the recent TAC meeting will require an extension and solicitation of additional funds from TAC members. |

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| **Potential Implementation:**  We are working with the AASHTO SCOBS T-15 committee to have the results of the study incorporated into new AASHTO codes. Papers are being prepared. |