**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(264)** | **Transportation Pooled Fund Program - Report Period:**\_ Quarter 1 (January 1 – March 31, 2016) **x Quarter 2 (April 1 – June 30, 2016)**\_ Quarter 3 (July 1 – September 30, 2016)\_ Quarter 4 (October 1 – December 31, 2016) |
| **Project Title:**Passive Force-Displacement Relationships for Skewed Abutments |
| **Name of Project Manager(s):**David Stevens | **Phone Number:** 801-589-8340 | **E-Mail** davidstevens@utah.gov |
| **Lead Agency Project ID:**FINET 42051, ePM PIN 10903UDOT PIC No. UT11.406 | **Other Project ID (i.e., contract #):** UDOT Contract No. 138123  | **Project Start Date:** August 13, 2012 |
| **Original Project End Date:**September 30, 2014 | **Current Project End Date:** December 15, 2016 | **Number of Extensions:**3  |

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** |
| $270,000.00 (current contract)$400,000.00 (total committed) | $172,300.00 | 75% |

***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 | 90% |

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| **Project Description**: At present, about 40% of the 600,000 bridges in the FHWA database are constructed at a skew angle (Silas Nichols, Personal Communication). There is considerable uncertainty about the passive force on skewed abutments where the passive force develops at an angle relative to the longitudinal axis of the bridge structure. Although current design codes (AASHTO 2011) consider that the ultimate passive force will be the same for a skewed abutment as for a non-skewed abutment, numerical analyses performed by Shamsabadi et al. (2006) indicate that the passive force will decrease substantially as the skew angle increases. Reduced passive force on skewed abutments would be particularly important for bridges subject to seismic forces or integral abutments subject to thermal expansion. Unfortunately, there have not been any physical test results for skewed abutments reported in the literature which could guide engineers in making appropriate adjustments for skewed conditions. Nevertheless, some field evidence has clearly shown poorer performance of skewed abutments during seismic events and distress to skewed abutments due to thermal expansion (Shamsabadi et al. 2006, Steinberg and Sargand 2010). This study builds on previous pooled fund testing conducted by Rollins and his students at BYU to evaluate passive force-deflection relationships for non-skewed abutments (TPF-5(122), Dynamic Passive Pressure on Abutments and Pile Caps, Rollins et al, 2010). The test facilities can readily be modified to allow for the test program with relatively small additional costs because of the test fixtures (reaction shafts, reaction walls, and pile supported cap) which are already constructed at the site. Results from this study can be compared with previous testing to assess overall performance.Four objectives are outlined for this new study: 1. Determine static passive force-displacement curves for skewed abutments with and without wingwalls from large scale tests.
2. Provide comparisons of behavior of skewed abutments with that of normal abutments.
3. Evaluate the effect of wingwalls on skewed abutment response.
4. Develop design procedures for calculating passive force-displacement curves for skewed abutments.

The scope of work consists of twelve specific tasks, including new tasks 7 through 12: 1. Literature Review and Collection of Existing Test Data
2. Perform Laboratory Passive Force-Deflection Tests on 2 ft High Wall with Skew Angles of 0º, 15º, 30º, and 45º
3. Perform Field Passive Force-Deflection Tests on 5.5 ft High Wall with Skew Angles of 0º, 15º, and 30º and Transverse Wingwalls
4. Perform Field Passive Force-Deflection Tests on 5.5 ft High Abutment with Skew angles of 0º, 15º, 30º and MSE Wingwalls
5. Calibrate Computer Model and Conduct Parametric Studies
6. Preparation of Final Report
7. Perform Additional Field Passive Force-Deflection Tests on 5.5 ft High Abutment with a Skew Angle of 45º with and without MSE Wingwalls
8. Perform Field Passive Force-Deflection Tests on 3.0 ft High Unconfined Backfill with Skew Angles of 0º and 30º
9. Perform Field Passive Force-Deflection Tests on 5.5 ft High Pile Cap with Concrete Wingwalls and Skew Angles of 0º and 45º
10. Perform Field Passive Force-Deflection Tests on 3.5 ft High Unconfined Gravel Backfill with Skew Angles of 0º and 30º
11. Perform Field Passive Force-Deflection Tests on 3.5 ft High GRS Gravel Backfill with Skew Angles of 0º and 30º
12. Present the Results of the Study at TRB and AASHTO Meetings

Dr. Kyle Rollins of BYU is the Principal Investigator for this research project. Individual task reports will be prepared for Tasks 1 through 5 and 7 through 11 when these are completed. Two in-person meetings with the multi-state technical advisory committee (TAC) were held in Salt Lake City, Utah during the project. Other TAC meetings will be tele-conference or web meetings. |

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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 – 80% complete. Continued work on RC Wingwall case.Task 6 – 50% complete. Progress was made on multiple draft final reports to be published. UDOT and the TAC continued reviewing draft final reports. Planned list of final reports is as follows:* Passive force-deflection behavior of 5.5 ft skewed abutments with transverse wingwalls (45 degree skew tests added)
* Passive force-deflection behavior of 5.5 ft skewed abutments with longitudinal MSE wingwalls (45 degree skew tests added)
* Passive force-deflection behavior of 3 ft skewed abutments with transverse wingwalls (larger width-to-height ratio tests) *– draft received*
* Passive force-deflection behavior of 5.5 ft abutments with longitudinal reinforced concrete wingwalls *– draft received*
* Passive force-deflection behavior of 3.5 ft gravel and Geosynthetic Reinforced Soil (GRS) backfill with transverse wingwalls *– draft received*
* Computer model calibration and parametric studies, Part 1 – Passive force-deflection modeling with no wingwall *– draft received*
* Computer model calibration and parametric studies, Part 2 – Additional modeling with longitudinal reinforced concrete wingwalls, 45 degree skew, two-lane highway
* Summary report on passive force-deflection behavior of skewed abutments (short report up to 20 pages)

Task 7 – 80% complete. Continued data analysis and worked on task report.Task 8 – 90% complete. Draft final report for this task is complete.Task 9 – 90% complete. Draft final report for this task is complete.Task 10 – 90% complete. Combined draft final report for Tasks 10 and 11 is complete.Task 11 – 90% complete. Combined draft final report for Tasks 10 and 11 is complete.Task 12 – 80% complete. Dr. Rollins presented the updated research results and proposed code changes to technical committees at the 2016 AASHTO SCOBS annual meeting in Minneapolis, Minnesota, in June.TAC Meetings – Summary of the March 23, 2016 TAC meeting was distributed to the TAC.Contract – Dr. Rollins and Caltrans updated the work plan for a new field testing task involving passive force/skewed abutments using controlled low-strength material (CLSM) as backfill and baseline push-and-rotate tests. UDOT sent Dr. Rollins a copy of a cellular concrete special provision for reference. |
| **Anticipated work next quarter:**Task 1 – None.Task 2 – None.Task 3 – None.Task 4 – None.Task 5 – Continue work on RC Wingwall case.Task 6 – Continue work on multiple draft final reports to be published, including UDOT and TAC reviews. Combine portions of other task reports for the Final Summary Report.Task 7 – Complete the draft final report for this task.Task 8 – Revise the draft final report for this task based on TAC feedback.Task 9 – Revise the draft final report for this task based on TAC feedback.Task 10 – Revise the draft final report for this task based on TAC feedback.Task 11 – Revise the draft final report for this task based on TAC feedback.Task 12 – Refine proposed code changes with the TAC in preparation for 2016-2017 interaction with AASHTO SCOBS. Prepare to publish a peer-reviewed paper on the study as a reference that could be noted in the code. TAC Meetings – Plan to hold a web conference TAC meeting this quarter to discuss new results, report reviews, and implementation.Contract – Add some baseline push-and-rotate tests on the test abutment/pile cap into the CLSM proposed additional work plan. The contract will be amended for the new tasks, schedule, and budget. Work will begin on the new field testing. Identify additional funding needs and sources with the TAC. |

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| **Significant Results:**During the past quarter we have been working to complete the finite element analysis and report. This report is now approximately 60% complete. Analyses have been completed for several models with the same reinforced concrete wingwalls but with different widths. The results indicate that the effect of the wingwalls becomes relatively insignificant as the width of the abutment increases to that for a typical two lane highway. Prof. Rollins attended the AASHTO SCOBS T-3 Seismic Design committee meeting in Minneapolis, Minnesota this past June and made a 30-minute presentation on the results of the pooled fund study. In addition, he suggested potential code changes where the results of the study could be incorporated into the AASHTO code. The presentation was very well received and we have laid the groundwork for implementing the results of the study into engineering practice. Ballots could be prepared for this coming December. Some committee members felt it would be helpful to publish a peer-reviewed paper on the study as a reference that could be noted in the code. We are planning to submit a summary article on the research to the ASCE Journal of Geotechnical and Geoenvironmental Engineering for review in the next quarter. |
| **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).**Reports are being completed relative to first 12 work tasks. Additional work tasks related to CLSM backfill tests are being added at the request of Caltrans and Utah DOT. Once the work plan for additional field testing with CLSM backfill and push-and-rotate tests is prepared, this will be incorporated into a new contract amendment which will also extend the contract end date. |

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| **Potential Implementation:** UDOT is considering early adoption of the skew reduction factor for passive force based on the laboratory and field test results. In June of 2013, 2014, and 2016, Dr. Rollins presented the results of the research to date to technical committees at the AASHTO Subcommittee on Bridges and Structures Annual Meetings in Oregon, Ohio, and Minnesota on behalf of the project TAC. This interaction is intended by the TAC and Dr. Rollins to prepare the way for design code revisions once the research is completed. Caltrans is also promoting use of the research results in their design methods. Dr. Rollins is proposing changes to the AASHTO code, and we will continue to promote these to the TAC and AASHTO SCOBS. |