**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, 2012) **\_** Quarter 2 (April 1 – June 30, 2012)**\_** Quarter 3 (July 1 – September 30, 2012)**x Quarter 4 (October 1 – December 31, 2012)** |
| **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:**5H06852H, 42051, ePM PIN 10903UDOT PIC No. UT11.406 | **Other Project ID (i.e., contract #):** UDOT Contract No. 13-8123  | **Project Start Date:** August 13, 2012 |
| **Original Project End Date:**September 30, 2014 | **Current Project End Date:** September 30, 2014 | **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** |
| $150,000.00 | $35,000.00 | 23% |

***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** |
| $35,000.00, 23% | $35,000.00 | 19% |

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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 six specific tasks: 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

Dr. Kyle Rollins of BYU is the Principal Investigator for this research project. Individual task reports will be prepared for Tasks 1 through 5 when these are completed. Up to two in-person meetings with the multi-state technical advisory committee (TAC) are planned to be 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.):**BYU prepared a task report for Task 2 and shared this with the TAC for review. A web TAC meeting was held in October to discuss results of the initial tasks, the schedule for remaining tasks, additions to the project scope based on new available funding, and the next TAC meeting. TAC members provided their input on which additions to the project scope would be preferred. BYU worked on preparing a revised project work plan.BYU completed field testing associated with Tasks 3 and 4 and worked on data reduction and analysis for these tasks. BYU prepared a preliminary field test report for Task 3 and shared this with the TAC for review. Both the Task 2 report and the Task 3 preliminary field test report were posted on the Transportation Pooled Fund project webpage. A TAC meeting was scheduled in Salt Lake City for February 2013.FHWA and Minnesota DOT added funding to this project, bringing the total funding commitments for the project to $255,000. |
| **Anticipated work next quarter**:The TAC will review the revised project work plan. The contract will be modified based on the approved revised work plan. A TAC meeting will be held in Salt Lake City in February 2013 to review progress and results to date and discuss next steps in the field testing. BYU will prepare a preliminary field test report for Task 4 and share this with the TAC for review. BYU will continue data reduction and analysis for Tasks 3 and 4 and prepare for additional field testing. Work will begin on Task 5 computer modeling and parametric studies. |

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| **Significant Results:**Testing and data reduction for Tasks 3 and 4 were largely completed during this quarter. These tests involved the pile cap with a height of 5.5 ft and a width of 11 ft. Task 3 tests involved an “unconfined soil backfill” which extended about 6 ft beyond the edge of the pile cap so that the shear zones could extend beyond the edge of the cap. Task 4 tests involved MSE wingwalls which paralleled the sides of the cap and extended 24 ft behind the cap. Load vs. deflection curve for the Task 3 tests involving 0, 15 and 30 degree skews are provided in Fig. 1. The passive force clearly decreased as the skew angle increased and the displacement at which the peak occurred decreased somewhat. These results are generally consistent with behavior of the lab test results where a plane strain geometry was enforced and suggest that the backfill geometry does not significantly affect the reduction in lateral resistance. Load vs. deflection curves for the Task 4 tests involving 0, 15 and 30 degree skews are provided in Fig. 2. Once again the passive force clearly decreased as the skew angle increased and the displacement at which the peak occurred decreased somewhat. These results are consistent with the lab tests and indicate that MSE wingwalls provide response similar to the plane strain conditions in the lab. Fig. 3 provides the data points indicating the reduction factors for passive force relative to the zero skew case. The results from the recent field tests generally fall in line with the results from previous lab tests and the numerical analyses performed by Shamsabadi (2006).Fig. 1 Passive force versus longitudinal deflection curves for 0°, 15°, and 30° skew angles from Task 3 tests.Fig. 2 Passive force-deflection curve for 0°, 15° and 30° skew tests with densely compacted granular backfill from Task 4.Fig. 3 Reduction factor, Rskew (passive force for a given skew angle normalized by passive force with no skew) plotted versus skew angle based on lab tests ([Rollins and Jessee 2012](#_ENREF_13)), numerical analyses ([Shamsabadi et al. 2006](#_ENREF_16)) and results from field tests in this study.  |
| **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).**After the original contract was authorized, additional funding was committed to the project by other states and FHWA. How to best utilize these funds on the project was discussed at the October TAC meeting and will be discussed further with the TAC as a revised contract is developed. With these new funds, the scope of work will be expanded to include more features in the field testing. This could cause the schedule to shift to compensate for the extra work. The recommended solution is to get input from the TAC and then modify the contract scope, amount, and schedule as needed, while limiting the shift in project 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 test results, but no final decision has been made at this point. With BYU’s help, UDOT plans to get the topic and research results on the agenda of the relevant AASHTO committee(s)/subcommittee(s) meetings in 2013. |