**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)  **x** **Quarter 3 (July 1 – September 30, 2012)**  \_ 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:**  801-633-6246 | | **E-Mail**  [davidstevens@utah.gov](mailto:davidstevens@utah.gov) |
| **Lead Agency Project ID:**  5H06852H, 42051, ePM PIN 10903  UDOT 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 | $0 | 5 |

***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 | 5 |

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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.):**  UDOT added funding to this project, bringing the total funding commitments for the project to $150,000. Dr. Rollins contacted members of the TAC with his responses to their review comments on the draft work plan. The work plan and contract documents were finalized, and the contract was authorized at the $150,000 amount.  Caltrans committed funding to the project, bringing the total funding commitments for the project to $200,000.  BYU began work on the project and completed Tasks 1 and 2. The majority of field testing associated with Tasks 3 and 4 was completed. A web meeting was scheduled for October with the TAC. |
| **Anticipated work next quarter**:  BYU will prepare task reports for Tasks 1 and 2 and share these with the TAC for review. A web TAC meeting will be 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.  BYU will complete field testing associated with Tasks 3 and 4 and work on data reduction and analysis for these tasks. A TAC meeting may be held in Salt Lake City later in the quarter or in early 2013. |

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| **Significant Results:**  In the Task 2 work lab tests were performed on a wall with skew angles of 0º, 15º, 30º, and 45º. The wall was 1.26 m wide and 0.61 m high and the backfill consisted of dense compacted sand. As the skew angle increased, the passive force decreased substantially with a reduction of 50% at a skew of 30º, which is in good agreement with prior finite element analysis by Shamsabadi at Caltrans. An adjustment factor was developed to account for the reduced capacity as a function of skew angle. The shape of the passive force-deflection curve leading to the peak force transitioned from a hyperbolic shape to a more bilinear shape as the skew angle increased. However, the horizontal displacement necessary to develop the peak passive force was still between 2 to 4% of the wall height. In all cases, the passive force decreased after the peak value, which would be expected for dense sand; however, at higher skew angles the drop in resistance was more abrupt. The residual passive force was typically 40% lower than the peak force which matched results from direct shear tests. For nearly all skew angles, the transverse shear resistance exceeded the applied shear force on the wall so that transverse movement was minimal. Computer models using the plane strain friction angle were able to match the measured force for the no skew case as well as for skewed cases when the proposed adjustment factor was used. Use of the lower triaxial friction angle significantly underestimated capacity.  Preliminary review of the field tests from Tasks 3 and 4 provide reasonably good agreement with the reduction factors obtained from the lab testing and numerical analyses. |
| **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 contract was authorized, additional funding was committed to the project by Caltrans. How to best utilize these funds on the project will be discussed at the October TAC meeting. With these new funds, the scope of work will most likely 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 schedule shift to keep the same 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. |