**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(296)** | **Transportation Pooled Fund Program - Report Period:** **x Quarter 1 (January 1 – March 31, 2015)** \_ Quarter 2 (April 1 – June 30, 2015)\_ Quarter 3 (July 1 – September 30, 2015)\_ Quarter 4 (October 1 – December 31, 2015) |
| **Project Title:**Simplified SPT Performance-Based Assessment of Liquefaction and Effects |
| **Name of Project Manager(s):**David Stevens | **Phone Number:** 801-589-8340 | **E-Mail** davidstevens@utah.gov |
| **Lead Agency Project ID:**FINET 42065, ePM PIN 12436UDOT PIC No. UT13.407 | **Other Project ID (i.e., contract #):** UDOT Contract No. 148753  | **Project Start Date:** March 6, 2014 |
| **Original Project End Date:**November 30, 2016 | **Current Project End Date:** November 30, 2016 | **Number of Extensions:**1 |

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** |
| $149,500.00 | $48,000 | 35% |

***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 | 40% |

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| **Project Description**:Liquefaction of loose saturated sands results in significant damage to buildings, transportation systems and lifelines in most large earthquake events. Liquefaction and the resulting loss of shear strength can lead to lateral spreading and seismic slope displacements, which often impact bridge abutments and wharfs, damaging these critical transportation links at a time when they are most needed for rescue efforts and post-earthquake recovery.While most updated seismic provisions now adopt a risk-targeted approach to design ground motions for superstructures, other critical aspects of geotechnical engineering, such as liquefaction and ground deformation evaluation, are still based on the older concept of deterministic hazard evaluation. Recent advances in performance-based earthquake engineering (PBEE) in geotechnical engineering (e.g., Kramer and Mayfield 2007; Rathje and Saygili 2008; Bradley et al. 2011; Franke and Kramer 2013) have introduced probabilistic uniform hazard-based procedures for evaluating seismic ground deformations within a performance-based framework from which the likelihood of exceeding various magnitudes of deformation within a given time frame can be computed. However, the ability to apply these performance-based procedures on everyday projects is generally beyond the capabilities of most practicing engineers.This study proposes to create and evaluate *simplified* performance-based design procedures for the *a priori* prediction of liquefaction triggering, lateral spread displacement, seismic slope displacement, and post-liquefaction free-field settlement using the standard penetration test (SPT).Objectives for this study include: 1. Derive new simplified performance-based procedure for liquefaction triggering, lateral spread displacement, free-field post-liquefaction settlements, and Newmark seismic slope displacements. 2. Develop liquefaction parameter maps in GIS format associated with each of the hazards included in objective 1 at return periods of 475 years, 1033 years, and 2475 years for each of the states participating in the study. 3. Evaluate the new simplified performance-based liquefaction procedures against conventional (i.e., AASHTO) liquefaction analysis procedures. 4. Develop a simplified design procedure that will allow the designer to envelope the performance-based and conventional results to select which result will govern the design.Tasks for this study include, regarding the participating states: 1. Derivation and validation of a new simplified liquefaction triggering model (Year 1). 2. Derivation and validation of simplified lateral spread displacement models (Year 1). 3. Derivation and validation of simplified post-liquefaction settlement models (Year 2).4. Derivation and validation of simplified Newmark seismic slope displacement models (Year 2).5. Assessment of grid spacing considerations in various seismic environments for map development (Years 1 & 2).6. Development of liquefaction parameter maps at targeted return periods in GIS file format (Years 1 & 2).7. Comparison of simplified, conventional, and deterministic analysis approaches (Years 1 & 2).8. Development of a simplified design procedure and an analysis spreadsheet that incorporates both performance-based and conventional methods (Years 1 & 2).9. Preparation of the annual and final reports (Years 1 & 2).10. Dissemination of results in appropriate engineering journals and conferences (Years 1 & 2). 11. Technical Advisory Committee meetings (Years 1 & 2), including a final workshop to train partner states on the new performance-based liquefaction hazard methods.Dr. Kevin Franke of BYU is the Principal Investigator for this research project. The technical advisory committee (TAC) for the study includes representatives from UT, AK, CT, ID, MT, and SC state 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 – 30% complete. BYU began work on this task.Task 4 – 30% complete. BYU began work on this task.Task 5 – 50% complete.Task 6 – 50% complete. Liquefaction triggering maps were re-developed and corrected based on selection of a different MSF relationship and shared with the TAC.Task 7 – 50% complete. BYU continued work on this task.Task 8 – 50% complete. The TAC quarterly update report for initial portions of Tasks 7 and 8 and the draft analysis spreadsheet were completed, and these were shared with the TAC. Revisions were made to the analysis spreadsheet based on TAC feedback, general de-bugging, and issues encountered with ActiveX buttons in Visual Basic macros.Task 9 – 50% complete. The annual (Year 1 update) report was completed and shared with the TAC.Task 10 – 50% complete.Task 11 – 50% complete. A TAC web-conference was held in March to review progress and to demonstrate use of the analysis spreadsheet.Contract – FFY 2015 funding from the study partners was added to the research contract to fully fund the planned scope of work. |
| **Anticipated work next quarter**:Task 1 – Completed.Task 2 – Completed. Task 3 – Simplified post-liquefaction settlement models will be derived and validated.Task 4 – Simplified Newmark seismic slope displacement models will be derived and validated. The TAC quarterly update report for Tasks 3 and 4 will be prepared and shared with the TAC.Task 5 – BYU will begin the Year 2 work on this task.Task 6 – BYU will begin the Year 2 work on this task.Task 7 – None.Task 8 – The draft analysis spreadsheet will be revised using feedback from the TAC.Task 9 – The annual (Year 1 update) report will be finalized based on feedback from the TAC.Task 10 – None.Task 11 – None.Contract – None. |

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| **Significant Results:**An Excel spreadsheet was built to perform the simplified performance-based liquefaction triggering and lateral spread displacement procedures. This spreadsheet is intended to be used in conjunction with the performance-based reference parameter maps that were developed last quarter. Values from these reference parameter maps can be entered into the spreadsheet with site-specific SPT/boring information to assess site-specific liquefaction triggering and lateral spread displacement at the desired hazard level. Place-holders in the spreadsheet were created for the 2015 research activities that include post-liquefaction free-field settlement and simplified Newmark sliding block assessment. A year-end meeting was held with the TAC to introduce them to the spreadsheet, to receive their feedback, and to receive guidance on the 2015 research activities. A few glitches with the spreadsheet were encountered, but were quickly resolved following the meeting. The draft year-end report was also discussed, and feedback was collected and implemented into the final year-end report. Research activities initiated on Tasks 3 and 4 of the research. Simplified performance-based procedures and their corresponding correction factors necessary to analyze post-liquefaction settlements and rigid Newmark sliding block displacements were begun, and are currently ongoing.  |
| **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).**Challenges were encountered during the development of the Excel spreadsheet for implementing the simplified performance-based procedures. A security update implemented by Microsoft in December 2014 rendered all of the ActiveX in the spreadsheet inoperable. A request of an additional $1,500 was made to completely re-design the spreadsheet so that it did not incorporate any ActiveX controls. The request was considered and granted by the TAC. The modifications to the spreadsheet were implemented as planned, and excluding the consideration of programming “bugs,” which are common and expected with any type of software development, all modifications and repairs were performed according to the anticipated schedule. |

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| **Potential Implementation:** With the completed spreadsheet and performance-based reference parameter maps, engineers can now effectively assess liquefaction triggering and lateral spread displacement at return periods of 475, 1033, and/or 2475 years for any site in the states of Utah, Idaho, Montana, Alaska, South Carolina, and Connecticut as long as site-specific SPT information is available.  |