**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, 2017)**  \_ Quarter 2 (April 1 – June 30, 2017)  \_ Quarter 3 (July 1 – September 30, 2017)  \_ Quarter 4 (October 1 – December 31, 2017) | |
| **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](mailto:davidstevens@utah.gov) |
| **Lead Agency Project ID:**  FINET 42065, ePM PIN 12436  UDOT 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:**  December 31, 2017 | | **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** |
| $179,500.00 (current contract)  $179,500.00 (total commitments) | $131,750.00 | 85% |

***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 | 80% |

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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 training meetings in each of the 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, OR, 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** – 100% complete.  **Task 4** – 100% complete.  **Task 5** – 100% complete.  **Task 6** – 95% complete. Work continued for Alaska and Oregon since the new USGS hazard tool became available. BYU continued working with the USGS beta tool.  **Task 7** – 100% complete.  **Task 8** – 97% complete. BYU continued updating the analysis spreadsheet based on TAC feedback. Some work remains for Alaska and Oregon.  **Task 9** – 97% complete. The TAC provided review comments on the draft final update report and the draft SPLiq user’s manual. Some work remains for Alaska and Oregon.  **Task 10** – 90% complete. Three new papers are under various stages of preparation. Three journal papers have already been published, and three peer-reviewed conference papers have already been published.  **Task 11** – 90% complete. Trainings in Oregon and Alaska will be held in spring/summer 2017.  **Contract** – Amendment was prepared to add funding, scope, and schedule to develop SPLiq reference parameter maps based on 2014 deaggregations for most of the TPF partner states, and based on 2008 deaggregations for Alaska. |
| **Anticipated work next quarter**:  **Task 1** – Completed.  **Task 2** – Completed.  **Task 3** – Completed.  **Task 4** – Completed.  **Task 5** – Completed.  **Task 6** – Mapping will continue for Alaska using the new 2014 USGS seismic source model  **Task 7** – Completed.  **Task 8** – BYU will continue updating the SPLiq spreadsheet tool. An online GIS database is being developed to house all of the computed reference parameter values.  **Task 9** – TAC final report will be revised by BYU based on TAC feedback and then published by UDOT.  **Task 10** – Papers under review will be either accepted or rejected for publication; work on additional journal and conference papers will continue.  **Task 11** – Trainings will be scheduled for Oregon and Alaska for the summer of 2017.  **Contract** – No changes planned. |

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| **Significant Results:**  The USGS NSHMP Uniform Hazard Tool is now operation for all 50 states, and reference parameter mapping using the 2014 USGS seismic source model has begun for Utah, Idaho, Montana, Oregon, South Carolina, and Connecticut. Reference parameter mapping using the 2008 USGS seismic source model has begun for Alaska. Currently we anticipate that the new reference parameter maps for the lower 6 states will be completed by May 31, and the new reference parameter maps for Alaska will be completed by July 31.  We are approximately 80% finished with a new online GIS database that engineers can use to obtain reference parameter values to use with SPLiq. This will remove the need for SPLiq to house the gridded reference parameter values, and will reduce the size of the spreadsheet considerably. |
| **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).**  We have been communicating closely with the USGS over the past quarter and have been reporting several bugs with their new Uniform Hazard Tool. For example, deaggregations could not be computed for any location in Alaska or South Carolina until the problem was resolved by the USGS in mid-April. The tool is now fully operational and running well as far as we can tell, and we have ten computers developing performance-based reference parameter values 24 hours per day. |

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| **Potential Implementation:**  Completion of the simplified analysis spreadsheet will allow engineers to implement performance-based liquefaction hazard analysis (i.e., triggering, lateral spread displacement, settlement, and seismic slope stability) at return periods of 475, 1033, and/or 2475 years for all of the states in the study. With the completion and validation of SPLiq, engineers will be able to quickly and easily perform probabilistic liquefaction hazard analysis on their projects at locations within the states for which reference parameter maps were developed. |