**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, 2018)**  \_ Quarter 2 (April 1 – June 30, 2018)  \_ Quarter 3 (July 1 – September 30, 2018)  \_ Quarter 4 (October 1 – December 31, 2018) | |
| **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:**  September 30, 2018 | | **Number of Extensions:**  5 |

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) | $167,000.00 | 93% |

***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**:  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** – 98% complete. Work continues with a few problem points in the 2014 hazard mapping of Montana and Oregon, which seem to have some issues with the USGS deaggregation files.  **Task 7** – 100% complete.  **Task 8** – 100% complete. SPLiq Version 1.3 was released to the TAC.  **Task 9** – 98% complete. Work continued on updating final reports based on TAC feedback.  **Task 10** – 100% complete. Three journal papers have already been published, and three more new papers are under various stages of preparation. Three peer-reviewed conference papers have already been published.  **Task 11** – 100% complete.  **Contract** – Extended the contract end date (no additional cost) to allow the BYU team to fix isolated problems with the Oregon and Montana reference parameter maps. |
| **Anticipated work next quarter**:  **Task 1** – Completed.  **Task 2** – Completed.  **Task 3** – Completed.  **Task 4** – Completed.  **Task 5** – Completed.  **Task 6** – Continue mapping and debugging for select points in Montana and Oregon with the USGS 2014 seismic source model.  **Task 7** – Completed.  **Task 8** – Completed. Based on input from TAC members, consider updating the SPLiq tool to (1) allow for input of two depths to water table, both the depth to water table during drilling and the design depth, and (2) allow for different sampler type at different depths.  **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** – Completed.  **Contract** – No changes planned. |

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| **Significant Results:**  The reference parameter maps using the USGS 2014 seismic source model have been completed for Utah, Idaho, South Carolina, and Connecticut. Some problem points remain in the mapping of Oregon and Montana. These points continue to be debugged. Preliminary results show that our efforts have resolved the issues in Montana. We have identified that human error may have resulted in the problem points in Oregon, and are in the process of re-analyzing those problem points to produce the most accurate reference parameter maps that we can. The reference parameter maps using the USGS 2008 seismic source model have been completed for Alaska. |
| **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).**  All delays have been overcome, and we are nearing completion of all assigned tasks (original and additional). Because of some unanticipated bugs with the USGS deaggregation files at select locations in Montana and Oregon, we have requested another extension until September 30, 2018 to deal with the bugs. Map development in Montana and Oregon is underway again after the bugs seem to be resolved.  ***The online reference parameter database temporarily went down due to a server crash at BYU. A temporary server has been setup to host the database:*** [***http://tethys-1.byu.edu/apps/lfhazard/map/***](http://tethys-1.byu.edu/apps/lfhazard/map/) |

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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.  In its recent revision of the Geotechnical Manual of Instruction (GMOI), the UDOT Geotechnical Division has added the Simplified SPT Performance-Based Assessment of Liquefaction and Effects procedure as UDOT’s preferred analysis method for liquefaction triggering, lateral spread, and seismic settlement. The SPLiq tool is now available on the Geotechnical Division’s website for in-house and consultant use on UDOT projects. |