**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(338)** | | **Transportation Pooled Fund Program - Report Period:**  \_ Quarter 1 (January 1 – March 31, 2016)  \_ Quarter 2 (April 1 – June 30, 2016)  \_ Quarter 3 (July 1 – September 30, 2016)  **x Quarter 4 (October 1 – December 31, 2016)** | |
| **Project Title:**  Simplified CPT 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 42074, ePM PIN 14239  UDOT PIC No. UT15.402 | **Other Project ID (i.e., contract #):**  UDOT Contract No. 169826 | | **Project Start Date:**  May 17, 2016 |
| **Original Project End Date:**  November 30, 2018 | **Current Project End Date:**  November 30, 2018 | | **Number of Extensions:**  0 |

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** |
| $93,000.00 (current contract)  $142,000.00 (total commitments) | $0 | 25% |

***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 | 25% |

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| **Project Description**:  Conventional “pseudo-probabilistic” procedures to evaluate liquefaction triggering and its effects have been shown through recent research to produce estimates of liquefaction factor of safety at inconsistent and often unacceptable levels of risk. These errors are introduced through the incorrect assumption that using probabilistic ground motions in a deterministic liquefaction analysis will yield a probabilistic estimate of liquefaction factor of safety. The inconsistent consideration of liquefaction risk could contribute to undesirable performance or even collapse of various important structures such as bridges or retaining walls in the event of an earthquake. Conversely, the inconsistent consideration of liquefaction risk could also potentially contribute to the unnecessary and expensive over-design of liquefaction mitigation alternatives. Utilization of a fully-probabilistic or performance-based liquefaction triggering procedure, which considers both uncertainty in the seismic loading and the liquefaction triggering relationship, could effectively solve these problems. Furthermore, probabilistic evaluation of liquefaction triggering could potentially be taken into account when considering liquefaction effects such as lateral spreading or free-field liquefaction settlements. However, current performance-based liquefaction procedures (e.g. Kramer & Mayfield 2007) are quite complex and beyond the level of practical application for most practicing engineers. Additionally, available performance-based methods generally focus on using the standard penetration test (SPT). Increasingly, the cone penetration test (CPT) is becoming a preferred instrument for performing in-situ assessment of liquefaction hazard. Development of code-compatible simplified approximations of performance-based analysis methods for the CPT to assess liquefaction triggering and its effects could be a viable solution to overcome these challenges.  Objectives for this study include:  1. Develop performance-based procedures for the CPT modeled after recent performance-based procedures for the SPT to compute the hazard from liquefaction triggering, lateral spread displacement, and post-liquefaction free-field settlement at select return periods (475, 1033, and 2475 years).  2. Develop simplified performance-based procedures for the CPT modeled after recent simplified performance-based procedures for the SPT to closely approximate the performance-based analysis results for liquefaction triggering, lateral spread displacement, and post-liquefaction free-field settlement at select return periods (475, 1033, and 2475 years).  3. Develop liquefaction triggering, lateral spread displacement, and post-liquefaction reference parameter maps in GIS format at return periods of 475 years, 1033 years, and 2475 years for each of the states participating in the study.  Currently funded contract tasks for this study include, regarding the participating states:  1. Develop full performance-based liquefaction triggering procedure  2. Develop full performance-based lateral spread procedure  3. Develop full performance-based post-liquefaction, free-field settlement procedure  4. Develop a numerical tool that will allow the calculation of performance-based liquefaction triggering, post-liquefaction settlement, and lateral spread displacement  11. Preparation of the Annual and Final Reports  12. Dissemination of Results  13. Technical Advisory Committee (TAC) Meetings  Dr. Kevin Franke of BYU is the Principal Investigator for this research project. The technical advisory committee (TAC) for the study currently includes representatives from UT, CT, OR, and SC state DOTs. |

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| **Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):**  **Task 1** – 95% complete.  **Task 2** – 90% complete.  **Task 3** – 100% complete. BYU completed and submitted the Year 1, Quarter 1 update report (Tasks 1-4) for TAC review.  **Task 4** – 80% complete. BYU continued developing the numerical computation tool, CPTLiquefY.  **Task 11** – No work yet.  **Task 12** – No work yet.  **Task 13** – 20% complete.  **Contract** – No changes made. |
| **Anticipated work next quarter**:  **Task 1** – Finalize uncertainty in the Boulanger and Idriss method; update report.  **Task 2** – Update the report.  **Task 3** – Complete and submit the Year 1, Quarter 2 update report for TAC review.  **Task 4** – Complete validation studies with CPTLiquefY. Complete and submit the Year 1, Quarter 3 update report for TAC review.  **Task 11** – None  **Task 12** – Begin preparation of two or three journal papers  **Task 13** – Plan to hold another TAC web-conference to review and discuss additional results from the study  **Contract** – Complete the 2nd year funding transfers to UDOT. Amend the contract with the additional funding to execute the 2nd year scope activities. |

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| **Significant Results:**  Research progress has accelerated this quarter. Research students were successfully able to integrate the new offline USGS hazard deaggregation tool (beta version) with CPTLiquefY, which means that the program will be able to perform probabilistic liquefaction hazard analysis without connecting to the USGS servers. This should greatly assist with the development of liquefaction reference parameter maps in Year 2 of this project.  CPTLiquefY is nearly completed. Some minor coding is still required to complete the lateral spread displacement prediction functionality of the program, but all other components of the software have been completed and are currently under validation testing.  Additional placeholders have been added to the CPTLiquefY coding that would allow for the consideration of spatial variability in the soil profile and CPT sounding. While this effort is not currently being pursued because it is not part of this project’s scope of work, it could lead to future valuable research in which the consideration of spatial variability of soil layering is added to the performance-based liquefaction hazard analysis.  The draft Year 1, Quarter 2 update report has just been completed, and is submitted for TAC feedback and comments. |
| **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).**  None to report. |

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| **Potential Implementation:**  None to report yet. |