**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(350)** | **Transportation Pooled Fund Program - Report Period:**\_Quarter 1 (January 1 – March 31, 2019**)**\_ Quarter 2 (April 1 – June 30, 2019)\_ Quarter 3 (July 1 – September 30, 2019)**x Quarter 4 (October 1 – December 31, 2019)** |
| **Project Title:**Development of Next Generation Liquefaction (NGL) Database for Liquefaction-Induced Lateral Spread |
| **Name of Project Manager(s):**David Stevens | **Phone Number:** 801-589-8340 | **E-Mail** davidstevens@utah.gov |
| **Lead Agency Project ID:**FINET 42080, ePM PIN 15017UDOT PIC No. PL05.350 | **Other Project ID (i.e., contract #):** UDOT Contract No. 17-8236  | **Project Start Date:** September 8, 2016 |
| **Original Project End Date:**March 31, 2019 | **Current Project End Date:** April 30, 2020 (43 months) | **Number of Extensions:**1 |

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** |
| $140,000.00 (current contract)$140,000.00 (total TPF commitments, incl. Dominion Energy unlisted amount) | $65,000.00 (paid by UDOT)$51,420.45 (at the U. of Utah) | 80% |

***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** |
| This Quarter = 0% (paid by UDOT)This Quarter = 0% (at the U. of Utah)Total Project = 46% (paid by UDOT)Total Project = 100% (at the U. of Utah) | $0.00 (paid by UDOT)$0.00 (at the U. of Utah)(Funding for U of U student from MPC funds) | 91% |

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| **Project Description**:This research is being conducted in conjunction with the Pacific Earthquake Engineering Research (PEER) Center and various state DOTs via a pool-fund study managed by the Utah Department of Transportation (UDOT). The Mountain-Plains Consortium (MPC) is also providing funding for certain aspects of this study, under a separate contract with the University of Utah. The research topic addresses the need to improve empirical, semi-empirical, analytical, and numerical methods to estimate the amount of permanent ground displacement associated with liquefaction-induced lateral spread resulting from several major earthquakes. This scope of work addresses the development of a lateral spread community database as part of the PEER Next Generation Liquefaction Project (<http://peer.berkeley.edu/lifelines/projects/ngl/>). It does not address predictive model development for lateral spread evaluations, which is future effort planned by PEER but not included in this work plan. The primary outcome of this research is a vetted and community database of seismic, topographical, geotechnical and horizontal displacement measurements about case histories of liquefaction-induced lateral spread for further research and model development by other researchers and investigators under the auspices of the PEER Center (<http://peer.berkeley.edu/>). Secondary outcomes are web host and publishing required to house and disseminate this database and its supporting information. Phase I Tasks include:(1) Kickoff meeting and procurement of software (2) Development of data quality indicators/metrics, quality assurance, and database population protocols (3) Defining methods for quantifying the uncertainty of key inputs (4) Development and structuring of database (5) Selection of case histories (6) Obtaining and screening of case history information (7) Population of the case history database (8) Database dissemination (9) Screening criteria for lateral spread potential (10) Phase I ReportingPhase II Tasks are not finalized or funded.The principal investigators for this study are Drs. Steven Bartlett (U. of Utah), Steven Kramer (U. of Washington and PEER Research Executive Committee Member), Kevin Franke (Brigham Young University) and Daniel Gillins (NOAA and consultant). The technical advisory committee (TAC) for the study currently includes representatives from Utah, California, Oregon, and Washington State DOTs. The MPC is providing additional funding for the study. |

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| **Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):****Task 1** – Completed.**Task 2** – Completed. Draft documents to be included in the interim report. **Task 3** – In progress. This task will continue as other data are added to the dataset.**Task 4** – Completed.**Task 5** – Continuing.**Task 6** – Continuing.**Task 7** – Uploaded sample data set to UCLA database. **Task 8** – Limited U of U dataset has been uploaded to UCLA database as a trial.**Task 9** – TAC meeting was held on Dec. 17th, 2019 mainly on this screening criteria task.**Task 10** – Draft final report in progress.TAC meetings – TAC web conference was held on Dec. 17th, 2019 to discuss progress to date, next steps, and questions.Contract – No changes were made.Comments from Dec. 2019 TAC web conference from Steven Kramer, University of Washington, regarding Task 9 screening criteria approach:Hi David,I feel that Prof. Bartlett has laid out a clear and logical framework for incorporation of a lateral spreading screening criterion into a lateral spreading hazard evaluation.  The framework builds on the type of lateral spreading displacement model that he, along with Les Youd, pioneered in the early 1990s, updated in the early 2000s, and updated again with the work of Dan Gillins in the early 2010s.  I agree with his statement that the model has frequently been used for conditions that go beyond the ranges of the data upon which it was based, and would be happy to see that eliminated by incorporation of a screening methodology.  This set of models are very practical and, as such, have been widely used in geotechnical engineering practice for many years.With respect to development of the screening criteria described in the memo, I have a few specific comments:1. The predictive variables for screening in Eq. 1 are all relevant.  I wonder, given the recent experience in New Zealand, however, about the concept of an identifiable “critical layer,” particularly in the types of interlayered soil deposits that are frequently encountered in practice.  Cubrinovski has shown that profiles with a single continuous liquefiable layer exhibited much more severe manifestations of liquefaction than interlayered profiles whose cumulative thickness of liquefiable material was the same.  The applicability of those findings to the lateral spreading problem should be evaluated.
2. I would strongly recommend formulating Eq. 2 in terms of natural, rather than common (base 10), logarithms.  Displacements, like many other measures of structural and geotechnical response, are found to be lognormally distributed and lognormal distributions are expressed in terms of natural logarithms.  This would allow more convenient comparison of uncertainties (in terms of ln(DH) ) in lateral spreading displacement with uncertainties in other measures of response.
3. As stated above, the “Bartlett-Youd” formulation is very practical and also lends itself well to a performance-based implementation as Kevin Franke did so well in his Masters research.  In my opinion, future advances in lateral spreading displacement models are going to involve the use of ground motion intensity measures instead of (magnitude and distance) to describe the demands on liquefiable soil profiles.  Such formulations will be able to take advantage of the greatly increased amounts of data that are now available, the improved ground motion prediction equations that are now available, and improved analytical models that are also now available.  I suspect that some models of that type will come out of the NGL project when it moves to its model development phase, and it will be very interesting to see how well they compare to this sort of classical model.
4. I hope the developed screening procedure will allow use of both SPT and CPT data.  Liquefaction hazard evaluation practice is moving rapidly toward CPT-based procedures and more case histories with CPT data are available now.  The relative state parameter index framework developed by Ross Boulanger offers a simple and convenient way of combining SPT and CPT data that is consistent with critical/steady state concepts.

Those are the main comments that came to mind as I read the progress memo. Steven KramerComments from Tom Shantz (CALTRANS), Dec. 2019, regarding Task 9 screening criteria approach:While the proposed analysis looks very solid I would like to offer a suggestion:  Instead of regressing on Mw and r consider using a ground motion parameter instead (CAV5, PGV, PGA, Sa(T=1)?)  I presume Mw and r are attractive because they are readily available for all the case histories.  The downside is that they represent 2 more degrees of freedom in your model and you have very limited data.  I think it may be better to bring in a few more parameters (type of rupture, depth of rupture, Vs30) and use a modern GMPE to estimate an intensity parameter for your model.  This way your Mw and r dependence will be consistent with GMPE’s that are based on a far larger dataset.  I realize this represents more work up front to get the needed metadata, but it should simplify the model building and produce a more robust model that will be easier to defend.  Tom Shantz |
| **Anticipated work next quarter**:**Task 1** – Completed.**Task 2** – Completed**Task 3** – Continue to inventory methods of quantifying uncertainty and data quality.**Task 4** – Completed.**Task 5** – In progress. BYU is working on 2010 Maule, Chile; 2011 Tohoku, Japan, 2010 Darfield and 2011 Christchurch.**Task 6** – Obtaining data in progress.**Task 7** – Continue the population of data set for U.S. Case histories and uploading to UCLA database.**Task 8** – Not started.**Task 9** – Continued work on screening criteria.**Task 10** – Preparation of draft final report.TAC meetings – Consider having monthly web conference briefings with the TAC.Contract – No changes are planned. |

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| **Significant Results:****University of Utah**

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| **Case history** | **Site** | **Displacement vectors** | **Boreholes** | **Subsurface data rows** | **Topology points** | **Cross-checked** |
| **1964 Niigata** | F10 | 179 | 24 | 359 | 429 | In progress |
| G10 | 654 | 68 | 1574 | 256 | Completed |
| H9 | 155 | 4 | 92 | 235 | Completed |
| J9 | 442 | 45 | 192 | 297 | In progress |
| K8 | 285 | 4 | 62 | 302 |  |
| Total | 1715 | 145 | 2279 | 1519 |  |
|  |  |  |  |  |  |  |
| **1983 Noshiro** | South | 266 | 128 | 462 | 176 |  |
| North | 147 | 59 | 848 | 348 |  |
| Total | 413 | 187 | 1310 | 524 |  |
|  |  |  |  |  |  |  |
| **1971 San Fernando** | Jensen water plant | 69 | 33 | 494 | flatfile |  |
| Juvenile hall | 79 | 6 | 121 | flatfile |  |
| Total | 148 | 39 | 615 |   |  |
|  |  |  |  |  |  |  |
| **1964 Alaska** | Total | 14 | 20 | 411 |   |  |
|  |  |  |  |  |  |  |
| **1979 Imperial Valley** | Heber road | 29 | 7 | 135 | flatfile |  |
| River park site | NA | 4 | 62 | NA |  |
| Total | 29 | 11 | 197 |   |  |
|  |  |  |  |  |  |  |
| **1983 Borah peak, Idaho** | Whiskey springs | 3 | 3 | 54 | flatfile |  |
| Pence Ranch | 3 | 6 | 69 | flatfile |  |
|  | Total | 6 | 3 | 54 |   |  |
|  |  |  |  |  |  |  |
| **1906 San Francisco** | Mission creek zone | 9 | 8 | 92 | flatfile |  |
| South of market area | 7 | 7 | 80 | NA |  |
| Foot of market area | 3 | NOTE -> | NA |  |
| Total | 19 | 15 | 172 |   |  |
|  |  |  |  |  |  |  |
| **1987 Superstition Hills, California** |  | 7 | 2 | 53 | flatfiles |  |
|  |  |  |  |  |  |  |
| **1989 Loma Prieta, California** |  | 3 | 15 | 236 | flatfiles |  |
|  |  |  |  |  |  |  |
| **1999 ChiChi Taiwan** | Site C | 20 | 15 |  | flatfiles |  |
|  | Site C1 | 4 | 2 |  |  |
|  | Site B | 4 | 6 |  |  |
|  | Site M | 4 | 2 |  |  |
|  | Site N | 4 | 3 |  |  |
|  | Total | 34 | 23 | 2806 |   |  |
|  |  |  |  |  |  |  |
| **2010 Chile** | Lo Rojas port |  | 8 | 2494 | in progress | In progress |
|  | North and South Pier |  | 7 |  |
|  | Juan Pablo II Bridge |  | 8 | completed |
|  | La Mochita Bridge |  | 2 | completed |
|  | Llacolen Bridge |  | 6 |  |
|  | Mataquito Bridge |  | 6 |  |
|  | Tubul Bridge |  | 6 |  |
|  | Raqui 1 and Raqui 2 Tubul |  | 1 |  |
|  | Total | 0 | 21 | 2494 |  |  |
|  |  |  |  |  |  |  |
| **1990 Luzon Phillipines** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **1991 Costa Rica** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **1994 Northridge, California** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **1995 Kobe, Japan** |  | 1250 | 118 | 2953 |  |  |
|  |  |  |  |  |  |  |
| **1999 Kocaeli, Turkey** |  |  |  |  |  |  |
| **BIG SUM:** |  | **3631** | **597** | **13527** | **2043** |  |

 **Brigham Young University**

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| **Case History** | **Site** | **Displacement Vectors** | **Boreholes** | **Subsurface Data Rows** | **Topology Points** |
| **2010 Maule, Chile** | Juan Pablo II | 1 | 7 | 685 | In Progress |
| La Mochita | 3 | 2 | 45 |
| Llacolen | 3 | 5 | 235 |
| Lo Rojas Port Coronel | 1 | 8 | 1732 |
| Mataquito | 3 | 6 | 556 |
| Port Coronel | 5 | 7 | 575 |
| Tubul Bridge | 2 | 6 | 185 |
| Tubul Raqui | 2 | 1 | 40 |
| Total | 20 | 42 | 4053 | 0 |
|   |
| **2011 Tohoku, Japan** | Hitachinaka | In Progress | 2 | 30 | In Progress |
| Isobe | 3 | 68 |
| Sodegaura | 2 | 36 |
| Tone | 1 | 26 |
| Tokyo Bay | In Progress | In Progress |
| Total | 0 | 8 | 160 | 0 |
|   |
| **2010 Darfield, New Zealand (September)** | Avon River | 37 | In Progress | In Progress | In Progress |
| Bottle Lake | 3 |
| Heathcote River | 2 |
| Styx River | 10 |
| Courtenay Stream/Kaiapoi River | 19 |
| Total | 71 | 0 | 0 | 0 |
|   |
| **2011 Christchurch, New Zealand (February)** | Avon River | 53 | In Progress | In Progress | In Progress |
| Heathcote River | 6 |
| Courtenay Stream/Kaiapoi River | 3 |
| Total | 62 | 0 | 0 | 0 |

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| **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** **the agreement, along with recommended solutions to those problems).**The contract extension was requested by BYU. Contract extension end date is April 30, 2020. U of U is assisting BYU in completing their case histories and work on the screening criteria task during this extension. |

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