**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(433)** | | **Transportation Pooled Fund Program - Report Period:**  \_ Quarter 1 (January 1 – March 31, 2023)  \_ Quarter 2 (April 1 – June 30, 2023)  \_ Quarter 3 (July 1 – September 30, 2023)  **x Quarter 4 (October 1 – December 31, 2023)** | |
| **Project Title:**  Behavior of Reinforced and Unreinforced Lightweight Cellular Concrete for Retaining Walls | | | |
| **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 42096, ePM PIN 17824  UDOT PIC No. UT18.404 | **Other Project ID (i.e., contract #):**  UDOT Contract No. 20-9367 | | **Project Start Date:**  May 21, 2020 (contract) |
| **Original Project End Date:**  September 30, 2022 (scope) | **Current Project End Date:**  March 31, 2024 (scope) | | **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** |
| Total commitments = $337,500.00  Obligated to date = $337,500.00  (incl. $7,500 state match on FHWA contrib.)  Contract amount = $325,578.00  Remaining on contract = $129,765.00 | Contract spent = $195,813.00  Contract support = $428.01  Total spent = $196,241.01 | 85% |

***Quarterly*** Project Statistics (on this contract):

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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% | $0.00 | 94% |

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| **Project Description**:  Roadway widening over existing walls and embankments, conflicts with settlement-sensitive utilities, and accelerated schedule delivery have increased demands for alternative lightweight fill materials. Engineers and contractors are increasingly considering Lightweight Cellular Concrete (LCC) backfills for abutments, embankments, and Mechanically Stabilized Earth (MSE) retaining walls; however, the absence of a consistent design methodology has led to a wide range of design approaches with no consensus standard. The most common class of LCC used in previous highway projects does not strictly behave like a soil or like concrete and must be investigated as a new material for engineering applications. Controversy exists within the industry regarding whether LCC should be modeled as a frictional or a cementitious (cohesive) material. In addition, earth pressures for retaining wall design and potential failure mechanisms of LCC are poorly understood for retaining wall applications, including uncertainty in LCC interaction with internal wall reinforcement in MSE wall applications.  Objective: Measure engineering design parameters and failure mechanisms for unreinforced and reinforced LCC backfills based on large-scale laboratory tests.  Funded tasks for this study include the following:  1. Literature review and survey  2. Basic material properties lab testing  3. Unreinforced LCC large-scale testing  4. Reinforced LCC large-scale testing:   * Reinforced LCC Test 1 – MSE wall with LCC backfill, * Reinforced LCC Test 2 – MSE wall with LCC backfill against soil slope, * Reinforced LCC Test 3 – MSE wall test with lower strength LCC backfill, * Reinforced LCC Test 4 – Pull-out tests on MSE wall, and * Reinforced LCC Test 5 – MSE wall test with welded-wire reinforcement   5. Compare results with design methods  6. Final Reports for (a) the unreinforced LCC test and (b) the reinforced LCC tests  7. Meetings and dissemination of results  The Principal Investigators for this study are Dr. Kyle Rollins of Brigham Young University and Ryan Maw, a principal engineer at Gerhart-Cole, Inc. The technical advisory committee (TAC) for the study currently includes representatives from UT, CA, KS, LA, MI, NY, OR, and WA state DOTs and FHWA. TAC meetings will be held periodically during the study and are currently planned to be web conferences. |

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| **Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):**  **Task 1** – 60% complete. Continued the literature review and survey.  **Task 2** – 100% complete.  **Task 3** – 100% complete.  **Task 4** – 100% complete.  **Task 5** – 60% complete. Continued work on Detailed Interim Reports including key parameters from the reinforced tests. Shared the detailed interim report with the TAC on the Sliver fill MSE LCC test. The TAC reviewed it and provided comments.  **Task 6** – 60% complete.  **Task 7** – 70% complete. A virtual TAC update meeting was held on Oct. 31. See a summary below.  **Contract** – No changes to the contract were made this quarter. |
| **Anticipated work next quarter**:  **Task 1** – Continue the literature review and survey.  **Task 2** – Completed.  **Task 3** – Completed.  **Task 4** – Completed.  **Task 5** – Continue work on Detailed Interim Reports including key parameters from the reinforced tests. Address TAC comments in the updated interim reports that were previously reviewed.  **Task 6** – Address TAC comments in the updated Final Report for the unreinforced LCC test. Work on the Draft Final Report for the reinforced LCC tests.  **Task 7** – Consider holding another TAC update meeting (virtual) after more reports are completed.  **Contract** – No changes to the contract are planned. |

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| **Significant Results:**  Additional study reports are being prepared for TAC review. The plan and status for the study reports are shown below:   * **Short Interim Reports: (to post final on TPF website; BYU’s format; UDOT won’t publish)**   + Unreinforced LCC testing (posted on TPF website)   + Reinforced LCC Test 1 – MSE wall with LCC backfill (posted on TPF website)   + Reinforced LCC Test 2 – MSE wall with LCC backfill against soil slope (posted on TPF website)   + Reinforced LCC Test 3 – MSE wall test with lower strength LCC backfill (posted on TPF website)   + Reinforced LCC Test 4 – Pull-out tests on MSE wall (posted on TPF website)   + Reinforced LCC Test 5 – MSE wall test with welded-wire reinforcement (posted on TPF website) * **Detailed Interim Reports: (to post final on TPF website; BYU’s format; UDOT won't publish)**   + 1st MSE LCC test (draft received and TAC reviewed)   + Sliver fill MSE LCC test (draft received Nov. 2023 and TAC completed basic review)   + Lower strength MSE LCC test (draft submitted Jan. 2024)   + Pull-out resistance (draft submitted Jan. 2024)   + Welded wire reinforcement (draft almost ready)   + Slope stability (draft almost ready) * **Short Report: (to post final on TPF website; BYU’s format; UDOT won't publish)**   + Pile lateral analysis in MSE LCC * **Final Reports: (to post final on TPF website; UDOT’s format; UDOT will publish)**   + Unreinforced LCC RCC tests (draft received and TAC reviewed)   + Reinforced LCC tests (Lit. review, summary of all reinforced tests, comparison of all tests, pull-out resistance, and slope stability) (draft ready in a couple of months)   Summary of the Oct. 31, 2023 TAC update meeting presentation and discussion:   * Dr. Rollins reviewed some results from the unreinforced LCC tests and some of the MSE reinforced LCC tests, as well as MSE reinforcement pull-out tests in LCC (ribbed strips and welded wire mesh). * Out of three options shared, the group consensus was to model the pull-out resistance as frictional, extending the F\* curve to higher pressure with additional points, and likely using the power function curve equations. * Dr. Rollins discussed some additional slope stability analyses and back-calculated strength properties from LCC free-face tests. * Preliminary observations and conclusions were shared, including some design considerations. * TAC members shared some input on LCC design values (including strength properties) used on their projects. |
| **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).**  No delays at this time. Testing and analysis for this research were allowed to continue at BYU with additional health precautions related to COVID-19. |

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