TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT
Q4/2024

Lead Agency:
Washington State Department of Transportation (WSDOT)

INSTRUCTIONS:
Lead Agency contacts 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.

Transportation Pooled Fund Program Project # ***TPF-5(491)***	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 1 – December 31)

TPF Title (follow link to TPF webpage)**:**

Super-Elastic Copper-Based and Iron-Based Shape Memory Alloys and Engineered Cementitious Composites for Extreme Events Resiliency

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Lead Agency Project ID: UCB 1874	**Other Project ID (i.e., contract #):** T-1874	**Project Start Date:** 2022-12-01
Original Project Start Date: 2022-12-01	**Original Project End Dates:** Phase 1 - 2023-11-30 Phase 2 – 2025-11-30	**If Extension has been requested, updated project End Date:** N/A

Project schedule status:

☒ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

(A) Overall Project Statistics:

Commitments to date $ (3yrs)	Obligations to date $	% Obligated	Contracted to date $	Expended to date $	Expended to date as % of contracted	Completed this quarter $
400,000	350,000	88%	320,000	302,644	96%	17,356 (does not include Dec)

(B) Project Description:

The objective of this research project is to:

1. evaluate and test several innovative columns which have self-centering feature to provide minimum residual displacement after earthquake.
2. improve column serviceability after earthquake by decreasing damage and spalling of concrete within column plastic hinge region; and
3. provide cost comparison among columns having different engineered materials; and
4. develop self-centering column design specifications. Particularly, in this proposed research, the low-cycle fatigue characteristics, corrosion resistance, machinability and coupling mechanisms with traditional steel rebar, and cost of CAM, NiTiCo super-elastic alloy (SEA) bars and Fe-SMA shape memory alloy (SMA) bars are being studied.

Direct comparisons are made with Nickel-Titanium (NiTi) SEAs (and traditional steel reinforcing bars as applicable) to illustrate the advantages/disadvantages of each material. If successfully demonstrated for their suitable characteristics, the NiTiCo SEA and Fe-SMA bars could replace their NiTi counterparts at a significantly lower cost and accelerate their applications in bridges. Therefore, the outcomes of this project are directly relevant to state departments of transportation and bridge and structural engineers and designers. This proposed project will build on the success of previously implemented WSDOT's application of shape memory alloy/engineered cementitious composite (SMA/ECC) in the columns of the SR-99 on-ramp bridge in downtown Seattle while making a direct impact on advancing and securing the national transportation network.

(C) Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

In this quarter, several iterations of the heat treatment technique on NiTiCo bars were performed to find the optimal approach that provides both superelastic properties and ductility. The implementation of NiTiCo bars into columns and connections with the traditional steel reinforcement outside of the plastic hinge region requires mechanical coupling. Headed coupling approach is adopted in this project which has various advantages: compatibility with traditional steel reinforcement, quick installation, and no loss of cross-sectional area of the NiTiCo bars. However, the headed coupling introduces heat affected zones at the ends of the bars, which result in reduced superelasticity and ductility. To overcome these limitations, heat treatment before and after has been investigated. The research team has identified the correct heat treatment approach after several trials, and it is currently in the final testing stages. Additionally, the Engineered Cementitious Composites (ECC) that will be used in the plastic hinge region of the two self-centering columns that will be tested is being developed. Specifically, the materials have been ordered, and several trial mixes have been made to achieve the desired properties. The forms and steel reinforcement cages for the two self-centering columns that will be tested in the upcoming quarter have also been fabricated.

(D) Anticipated work next quarter:

In the next quarter, we will complete the material tests on the NiTiCo bars and ECC. Once the material tests are completed, the two self-centering columns will be fabricated and tested under simulated seismic loading. The test data will be processed and evaluated.

(E) Significant Results:

The significant result in this quarter is the identification of the correct heat treatment technique to achieve the desired properties of the headed NiTiCo bars. Additionally, necessary materials and forms have been ordered/assembled for column construction.

(F) 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).

The TAC unanimously voted to continue the work and Phase 2 was broken up into smaller tasks to try and match the amounts available through obligated funds. A task proposal was requested from the researchers for Task 3a and adopted after comments by the SMEs and revision by USC for a task order to the value of $90k. This task included fabrication and testing of two columns at the end of which, given the funding continued with two more columns.

Following further funds being available through recent obligation transfers, the work was extended to include testing of the remaining two columns under Task 3b and electrochemical testing under Task 4 under a new task order for $110,000. This work is per the original scope of work as identified in the proposals.

Currently there is a proposal that is being evaluated by WSDOT for $100,000 to perform Task 5 on quantifying the cost impact of using CAM and Fe-SMA SEAs by comparing representative conventional bridges and their SMA/ECC counterparts.

USC has also indicated that there have been significant inflationary factors that are affecting labor rates. This will necessitate increasing the commitments needed to complete the project and WSDOT has been collaborating with the FHWA, TAC partners and USC to address and resolve this. It is important to note that the projected adjustment is well within the national inflationary trend over the duration of this program and will not affect the cost and scope of the existing task orders.

(G) Potential Implementation:

We will have a better idea on the implementation trajectory of the findings during Phase 2, within the scope of this pooled fund, if successful and if adequate funding is committed and obligated to conduct Phase 2. The results of Phase 1 look very promising so far!