TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): **Indiana 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.

Transportation Pooled Fund Program Project # TPF-5(471)	**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)

Project Title: Real-time monitoring of concrete strength to determine optimal traffic opening time

Name of Project Manager(s): Tommy Nantung	**Phone Number:**	**E-Mail** tnantung@indot.in.gov
Lead Agency Project ID: TPF-5(471)	**Other Project ID (i.e., contract #):**	**Project Start Date:** June 1, 2021
Original Project End Date: May 31, 2023	**Current Project End Date:** May 31, 2023	**Number of Extensions:**

Project schedule status:

☒ On schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$375,000	$8,000	3%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$8,000	3%

Project Description

Background

The Pooled Fund Project TPF-5(471) is led by Indiana DOT with participation from FHWA, Texas, Missouri, Tennessee, Colorado, North Dakota, and California. The project has been funded with a total of $375,000 for a span of three years.

Fast-paced construction schedules often expose concrete pavement and/or structures to undergo substantial loading conditions even at its early age, which causes pre-mature failure or a significant reduction in the life span of pavement and bridges. Current methods for determining traffic opening times can be inefficient and expensive, causing construction delays and cost overruns. For instance, maturity testing and flexural testing of concrete are two commonly used methods. The maturity test requires extensive calibrations of the maturity meter and trial batches for each mix design, causing inefficiency and high costs. The flexural strength testing of concrete beams often provides unreliable results due to the differences between laboratory and field conditions. It is also time and labor-consuming.

To address this critical need, INDOT and Purdue University have developed an in-situ nondestructive sensing method that enables direct measurement of concrete stiffness and strength using electromechanical impedance (EMI) method coupled with piezoelectric sensors. It proved to be reliable for in-situ monitoring of concrete strength development regardless of mix design (e.g. fly ash, slag and silica fumes). We have also set a precedent for the reported strength property of concrete at the very early age of 4-8 hours. These properties could not be obtained using conventional cylinder testing as concrete is often not hard enough to be demolded at this point. This has also proved that the sensing method does not need any calibrations for different concrete mix designs during each test run, which has been significantly cumbersome for maturity testing.

Even though the novel EMI method developed by INDOT and Purdue University can accurately measure the concrete strength in real-time without any database or calibration, the method cannot be deployed in fields. The data acquisition and processing tools consist of heavy and bulky equipment which can cause safety concerns on construction sites. To address these problems, the project will initially focus on development of on-chip device to acquire and process EMI data with wireless capabilities. Such a device can then be deployed on transportation construction sites and can transfer the concrete strength data to project managers or superintendents remotely using wireless capabilities. The EMI concrete sensors will be installed and tested in construction sites and various concrete mixes of participating DOTs. Feedbacks from the DOTs' project managers and superintendents will be considered and the sensing technology will be improved.

The ultimate goal of this pooled-fund study is to develop the standard testing procedure for field testing by implementing it in all the participating states and develop AASHTO ready specifications for using this method. A detailed cost/benefit analysis of this method along with a set of recommendation for traffic opening time and maintenance schedule will be conducted during the program.

Project Objectives

The objectives of the proposed pooled-fund study are as follows:

1) Develop the field implementable wireless sensing technology enabling data automation and transmission.
2) Implement the smart sensing methods in all participating states and train state engineers to effectively use the sensing methods.
3) Provide guidance on how to use EMI methods to determine the optimal traffic opening time of concrete pavement, maintenance and repair schedule.
4) Develop AASHTO ready specifications

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

June 1 – June 30, 2021

- Conducted a conference meeting with representatives from DOTs of Indiana, Colorado, Texas, California, Tennessee, and North Dakota. Following were the topics of discussions
  - Prior accomplishments from INDOT and Purdue team relevant to the pooled fund project
  - On-going works
  - Project objectives and timeline
  - Plan and recommendations for next works
- Work on initial design and development of sensors and data loggers with data storage has been started
- Discussions on mix designs to be tested have been initiated with participating DOTs

Anticipated work next quarter (July 1 – September 30)**:**

- Initiate development of automated concrete strength data storage so that personnel does not need to manually acquire and process the data from sensors
- Identify and test electronic components to build handheld-sized data loggers for the sensors with wireless capabilities
- Start reviewing concrete mix designs used by participating DOTs
- Continue discussions with officials from participating DOTs regarding recommendations on desired features in the developing sensing technology

Significant Results:

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).

Potential Implementation:

- Anticipated implementation of the developing sensing technology in bridges and pavements of participating DOTs in years 2-3 of the project
- Anticipated implementation in interstate highways in the year 3 of the project