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Research Notes

Real-time monitoring of concrete strength to determine optimal traffic opening time [TPF-5(471)]

Develop a non-destructive, field-ready method to monitor early-age concrete strength.

Pavement

MAY 2025

Project Title:
Real-Time Monitoring of Concrete Strength to Determine Optimal Traffic Opening Time [TPF-5(471)]

Task Number: 4012

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WHAT IS THE NEED?

Accelerated construction schedules often subject young concrete to early loading, risking premature failures and reducing the lifespan of pavements and bridges. Current methods for determining traffic opening times, such as maturity testing and flexural beam testing, are inefficient, costly, and time-consuming.

Supported by the Indiana Department of Transportation (Lead Organization), this study developed a promising non-destructive method using electromechanical impedance (EMI) sensors with piezoelectric technology. Lab-scale testing demonstrated reliable, early-age (4–8 hours) strength monitoring, offering a faster, simpler alternative to conventional approaches.

WHAT ARE WE DOING?

This pooled-fund study includes:

- Developing field protocols to assess in-situ concrete strength, stiffness, and hydration behavior.
- Creating a user-friendly graphical interface for data interpretation.
- Conducting field implementation and training in participating states.
- Providing guidelines and specifications for EMI sensor use based on national data.
- Developing American Association of State Highway and Transportation Officials (AASHTO)-ready specifications for the smart sensing method.

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WHAT IS OUR GOAL?

The goal of this study is to deliver a field-deployable, wireless EMI-based sensing system, implement it in participating states, and develop AASHTO specifications for its use.

WHAT IS THE BENEFIT?

This technology will give the California Department of Transportation (Caltrans) a reliable, efficient tool to determine optimal traffic opening times, reducing delays and cost overruns in concrete pavement construction.

WHAT IS THE PROGRESS TO DATE?

The wireless, field-ready EMI concrete strength sensing system continues to advance. Key achievements include:

- Over 800 REBEL Sensors deployed across 100+ projects, demonstrating wider field implementation.
- Enhanced LTE outage management to store and forward telemetry data during connectivity issues.
- Ongoing improvements to battery efficiency for pour detection systems.
- Development of a diagnostic tool for more efficient gradient flow in machine learning models, improving overall performance.
- Post-processing methods refined for smoother strength prediction continuity, reducing data variability compared to traditional cylinder break tests.
- Dashboard upgrades now show battery life, sensor IDs, and datalogger IDs for better tracking.
- Machine learning model improvements resulting in more accurate strength sensing outputs.

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