

# Executive Summary, Research Readiness Level Assessment, and Technology Transfer

## Low-Cement Concrete Mixture for Bridge Decks and Rails

### Research Objectives

The main objective of this research is to develop concrete mixtures with reduced cement content for bridge decks and rails to minimize early-age shrinkage cracking. By optimizing aggregate packing and conducting thorough experimental assessments, the study seeks to enhance performance and durability. Anticipated outcomes include prolonged service life of bridge components, reduced disruptions from repair work, and cost and environmental benefits associated with lower cement usage.

### Research Benefits

This study provides an alternative concrete mixture for bridge decks and rails, less prone to early-age shrinkage cracking. By using less cement, it reduces concrete costs and environmental impact, offering economic and sustainability benefits.

### Principal Investigator

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### NDOT Lead TAC Member

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### Background

According to the United States (US) Federal Highway Administration (FHWA)'s National Bridge Inventory (NBI) database of 2022, 36% of U.S. bridges need repair work and 3% (5,920) need deck repair or replacement. A common cause of concrete bridge deck and rail deterioration is early-age shrinkage cracking, primarily attributed to the drying shrinkage of restrained concrete (Deng et al., 2016). These cracks commonly occur immediately after construction and even before the bridge is open to traffic. The cracks are primarily in the transverse direction (perpendicular to traffic), with some longitudinal and diagonal cracks at the deck ends. The cracks accelerate the penetration of water, chemicals, and other impurities into the concrete, which leads to reinforcement corrosion, delamination, and eventually concrete spalling. This common deterioration problem results in shorter service life, road closures, and costly repairs and replacements.

### Conclusion

The study focused on developing and evaluating concrete mixtures with reduced cement content for bridge decks and rails. By optimizing aggregate gradation, the research achieved a reduction of up to 23% in cementitious material content without compromising performance significantly. These reduced cementitious materials concrete (RCMC) mixtures showed improved crack resistance, durability, and strength compared to conventional mixtures. While RCMC mixtures had slightly lower workability and longer setting times, they maintained similar mechanical properties and displayed comparable or better durability in tests such as freeze-and-thaw resistance and chloride penetration. Overall, RCMC mixtures offer potential cost savings and sustainability benefits for concrete construction projects while ensuring structural integrity and durability.

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**Interested in finding out more?**

**Final report is available at:**

[NDOT Research Website](#)

### NDOT Recommendations Based Off Research Project

Upon the completion of this research project, M&R has evaluated the mechanical properties to ensure workability and constructability so that the mixes can be easily used in engineering applications. The performance testing indicated that reducing a bag (94 Pounds) met mechanical properties (Compressive Strength, Modulus of Elasticity and Flexure strength) comparable to the 47BD control. The next step will be to evaluate the constructability and monitor the performance of the developed mix design in a real application, such as cast-in-place concrete bridge deck or rail construction. NDOT Bridge Division has selected a project in District 8, which will be constructed in 2025.

- *As provided by Wally Heyen and Fouad Jaber, Lead TAC Members*

### Research Readiness Level (RRL) Assessment

**Level : Implementation with Follow-up for 5 years**

**RRL 4**

### Technology Transfer

#### Transportation Research Board (TRB) papers and Publications

- Das, S., Morcous, G., and Hu, J. (2024) "Development of Reduced Cementitious Materials Concrete (RCMC) Mixture for Bridge Decks and Rails", 2024 Bridge Engineering Institute (BEI) Conference, Las Vegas, July.

#### Webinars/Presentations

- Reducing Early-Age Shrinkage Cracks of Bridge Decks and Rails, Poster presentation at the 2022 UNL Research Fair

**This brief summarizes Project SPR-FY22(001)  
"Low-Cement Concrete Mixture for Bridge Decks and Rails"  
Nebraska Department of Transportation Research Program**