VERMONT
AGENCY OF TRANSPORTATION

FACT SHEET

Development of Cost-Effective Rapid-Setting Concrete for Improved Bridge Joint Performance

PROJECT TITLE

Development of Cost-Effective Rapid-Setting Concrete for Improved Bridge Joint Performance

STUDY TIMELINE

July 2021 – December 2023

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KEYWORDS

Accelerated Bridge Construction, Rapid Setting Concrete, Laboratory Testing, Durability.

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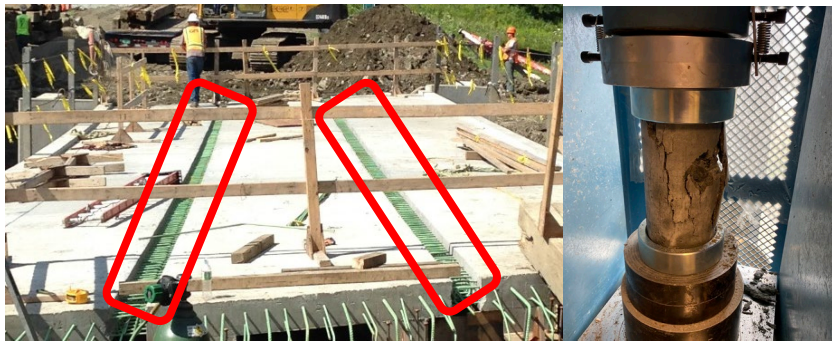
VTRC021-003
$142,999

University of New Hampshire

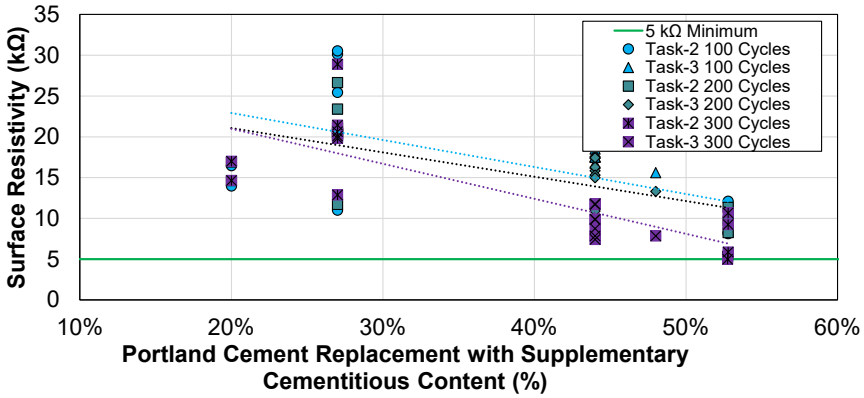
More information about the VTrans Research Program, including additional Fact Sheets, can be found at: http://vtrans.vermont.gov/planning/research

Introduction or Problem Statement

Vermont Agency of Transportation (VTrans) was an early adopter of the accelerated bridge construction (ABC) approach and has led the nation in using ABC to successfully deliver bridge construction and reconstruction projects. While ABC projects enjoy high material quality due to a large fraction of precast and prefabricated elements, connections between these elements must be placed in-situ, these are often treated as a "weak-link" due to potential risk for inferior performance. VTrans has adopted the use of rapid-setting concrete (RSC) for construction of connections between precast elements in ABC (see figure below showing an example of connection on a VTrans ABC project), which follows the current state of practice. Current VTrans practice dictates use of a membrane and overlay on ABC projects due to concerns of poor durability of RSC in ABC connections. Durability concerns that have prevented use of bare decks have not been studied or evaluated. This study comprehensively assessed durability of RSC used by VTrans for ABC connections and proposed proportion based standardized mix designs to lower costs.



Left: VTrans ABC Connections (in red boxes) ready for RSC placement
Right: RSC Mix design being tested for its compressive strength



Effects of Portland cement replacement with supplementary cementitious content on the chloride ingress potential of rapid setting concretes at different levels of freeze-thaw cycling.

Methodology or Action Taken

This research study is focusing on an extensive laboratory evaluation of currently used RSC by VTrans to assess durability of these materials as well as to assess their structural performance. Testing scope includes strength (compressive and flexural), elastic modulus, chloride permeability, and bond capacity measurements for several RSC materials that have been used on VTrans ABC projects. Lab tests were conducted on control specimens as well as those with laboratory-imposed freeze-thaw cycling. Further, several variations on RSC mix designs used in past were evaluated through two-phased experiments (phase-I (task-2) used partial factorial experimental design and phase-II (task-3) design only varied a single variable at a time). Twenty RSC materials were comprehensively evaluated.

Conclusions and Next Steps

Comprehensive literature review found that that limited work has been conducted to comprehensively assess durability of RSC with respect to use in ABC connections, however a significant amount of literature is based on developing RSC as a rapid setting patching and repair material. Laboratory evaluation conclusively demonstrated that there is not a concern for loss of durability in RSC materials due to freeze-thaw cycling, specimens with up to 300 freeze-thaw cycles maintained mechanical performance, bond strength and lower permittivity to chloride ions. Through statistical analyses of laboratory experimentation data, the research team has proposed material compositional limits for RSC materials that would reduce performance testing requirements for RSC used on individual projects. The target for total cementitious content of 850 lbs./yd^3 with 44% supplementary cementitious content is recommended. The final report is currently being reviewed by the project TAC.

Potential Impacts and VTrans Benefits

This research provides several potential benefits to VTrans that will improve the performance of bridges in the state as well as decreasing both initial and life cycle costs. The initial costs of ABC projects will be reduced via use of proportion-based RSC mix design(s) that are less prone to variability in properties; therefore, requiring less quality control tests. The life cycle costs of ABC projects will be reduced due to demonstrated durability of RSC materials which results in changes to agency practice that will eliminate the need for membrane and bituminous overlay treatments on ABC projects. Also, the improved and more cost-effective RSC material specifications will allow for an increased number of ABC projects as the structural performance will not be compromised; this has the potential to limit traffic disruption and overall construction time. The project outcomes have the significant potential to reduce the initial project costs and maintenance costs and provide VTrans with the means to repair or replace more structurally deficient bridges with a limited budget. The benefits of the project can be quantified from multiple perspectives:

- Initial project cost savings can be directly calculated using information on the cost of testing requirements within current quality assurance process.
- Potential initial project cost savings can be directly calculated by eliminating the need for membrane and pavement on ABC projects.
- Life cycle cost savings can be determined based on the expected improvements in performance and durability using the improved RSC designs, no future maintenance of membrane and pavements which have a lower design life and are prone to maintenance issues, and an increased resiliency in ABC projects.
- The decrease in traffic disruption for projects using ABC and RSC materials as compared to traditional construction can be determined; and,
- Contributions to sustainability aspects can be quantified, including reduction in carbon footprint.