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 – June 2023

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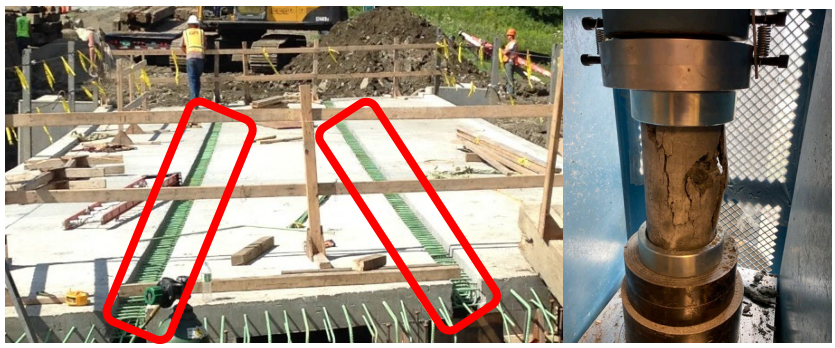
KEYWORDS

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

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 will comprehensively assess durability of RSC used by VTrans for ABC connections and explore options of 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

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 from last three years. Further, several variations on RSC mix designs used in past are being evaluated. A partial factorial experimental design is being employed for testing mix proportion variations. The objective of this effort is to assess suitability of standardized RSC designs that can be adopted by VTrans as part of standard material specifications.

Lab tests are being conducted on control specimen as well as those with laboratory-imposed freeze-thaw cycling. Limited evaluation is also planned on materials extracted from existing ABC connections for measurement of chloride ion penetration.

Conclusions and Next Steps

The research has completed its literature review and found 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. Research suggests that RSC connections need to have high durability performance for longevity and performance, particularly in bonding as RSC's ability to bond to precast elements is important to maintain its durability. This will result in mixes focused on use of shrinkage reducing admixtures as well as surface preparation of samples and precast elements. Research also suggests most RSC has a high cementitious content, resulting in greater shrinkage and brittleness, a concern that must be addressed.

The research team has collected more than five ton of cementitious materials, aggregates and chemical admixtures for testing. Tests on the previously used RSE mixes in VTrans projects is currently underway. At this moment, lab prodcued VTrans RSC mixes have shown lower workability than their plant produced counterparts, however, mixes have been adequate on strength.

The next steps for this research will be full initiation of its experimental design plan and lab testing, which includes 3 previously used mix designs and 9 variations off them.

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 development of 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 by assessing the durability of RSC materials as well as the durability of structural connections made with RSC materials via laboratory and in-situ tests. 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 per ABC projects and provide VTrans with the means to repair or replace more structurally deficient bridges with a limited budget. This will increase the overall condition of bridges across the state. 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.