Research Project Brief

# Report 26-R44: Entire Interior Culvert Lining with Engineered Cementitious Composites

VTRC Virginia Transportation Research Council

## Background

Corrugated metal pipes (CMPs) deteriorate from corrosion and abrasion, compromising hydraulic function and structural integrity. For advanced deterioration, spray-applied pipe lining (SAPL) offers a cost-effective alternative to full replacement, reducing traffic disruptions and construction costs. However, conventional cementitious SAPL materials often crack in service, limiting their effectiveness. Engineered Cementitious Composites (ECCs)—a special class of fiber-reinforced concrete (FRC) exhibiting strain-hardening behavior, resulting in exceptional ductility and crack control—present a promising solution for durable culvert rehabilitation.

*Cracks in Conventional Cementitious Liners*

## Research Objectives

The purpose of this laboratory and parametric study was to provide VDOT with practical sprayable ECCs and improved design guidance for the trenchless rehabilitation of CMPs, particularly for applications requiring repair of the entire culvert interior using SAPL.

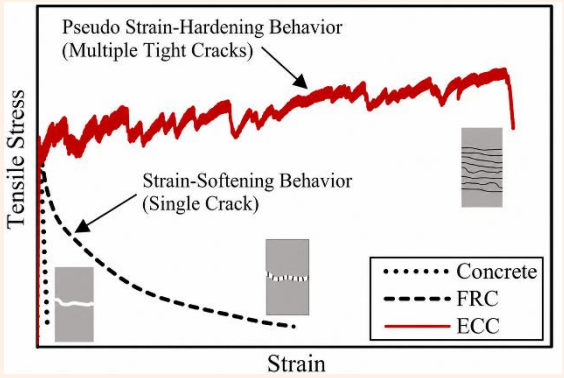
## Approach

Sprayable ECC mixtures were developed and tested in the laboratory using readily available materials to enhance field practicality. The mixtures incorporated air entrainment following the Temporary High Initial Air Content concept, which improves pumpability while maintaining thickness buildup.

A field trial was conducted to evaluate the feasibility of producing and pumping one of the newly developed ECC mixtures under real-world conditions.

A parametric study assessed existing liner thickness design methodologies.

Field inspections were conducted to evaluate the performance of conventional cementitious liners and ECC-repaired culvert inverts




*Tensile Response of Concrete, FRC, and ECC*

## Outcomes

ECCs incorporating air entrainment achieved consistency suitable for pumpability, sprayability, and thickness buildup, while maintaining strength, deflection-hardening, and durability.

The parametric study highlighted the need for more consistent design guidance and indicated that a 1- to 2-inch ECC liner thickness is sufficient to restore the structural capacity of most CMPs.

Field inspections revealed excellent performance of ECC-repaired inverts, with no cracking or debonding after up to 6.5 years in service, whereas conventional cementitious liners exhibited significant cracking within 3 to 4 years.

## Research Benefits

ECCs can extend the service life of culvert repairs by providing crack control and better long-term performance than conventional cementitious liners.

The liner thickness guidance provided offers VDOT engineers a more rational and consistent basis for design.

If widely implemented, ECC repairs could save VDOT approximately $7.3 million per year on culvert repairs, allowing these cost savings to be reallocated to other VDOT activities.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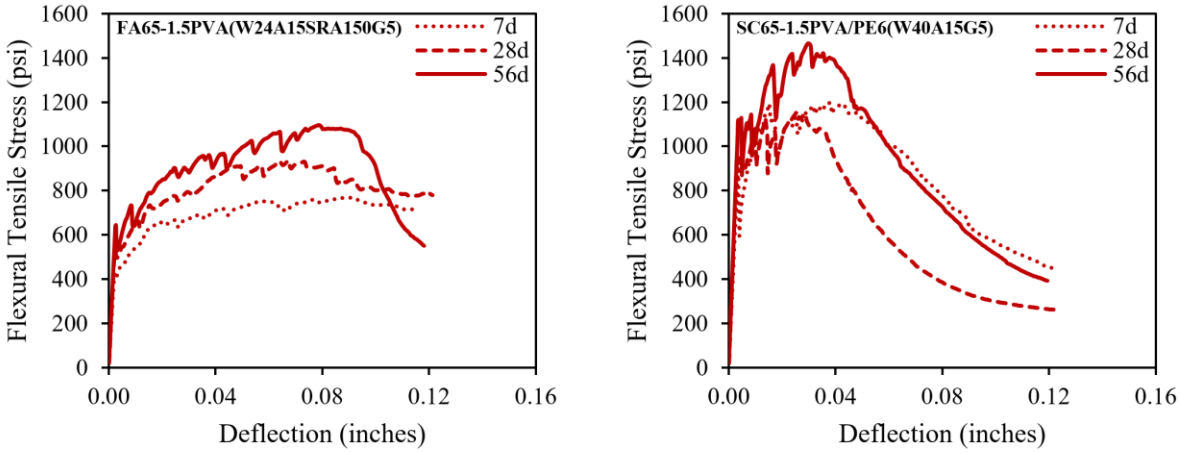
## Research Findings

*Field Trial of Newly Developed ECC*




*Flexural Tensile Stress versus Deflection Curves Showing Ductile Response of ECC Mixtures*

### ECC Development

ECCs incorporating air entrainment, achieved consistency suitable for pumpability, sprayability, and thickness buildup, while maintaining strength, deflection-hardening, and durability.

### Field Performance

Field inspections revealed excellent performance of ECC-repaired inverts, with no cracking or debonding after up to 6.5 years in service.