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Depth Beyond Knowledge™

JACOB TETREAULT, MASC (2016)

RESEARCH SUMMARY

INVESTIGATION OF TWO DIFFERENT CULVERT REPAIR METHODS—GROUTED SLIP-LINERS AND INVERT PAVING

SEMINAL EVALUATION OF IMPACT OF GROUT CHOICE ON PERFORMANCE OF SLIP LINERS

LOW DENSITY GROUT BEHAVIOUR LIMITED BY SHEAR FAILURE

HIGH DENSITY GROUT BEHAVIOUR LIMITED BY TENSILE FRACTURE

FIRST LABORATORY TEST OF PAVED INVERT TO ESTABLISH STRENGTH LIMITS

STABILITY LIMIT STATE ASSOCIATED WITH INVERT MOMENT IN REINFORCED CONCRETE

HIGHLIGHTS

- **Supported by donations from Uponor Infra Ltd, LafargeHolcim of Canada, Euclid Canada & Contech Construction Products**
- **Industry collaboration on sustainability rating module for Goldset, a decision support tool from Golder Associates**
- **Seminal work presented in 3 journal papers**

PERFORMANCE AND ASSESSMENT OF REHABILITATED STEEL CULVERTS

One component of a major strategic research project funded by NSERC, Jake Tetreault's graduate studies primarily involved full-scale testing of corroded metal culverts before and after repair. Two common culvert rehabilitation methods were examined— 1. insertion of a high density polyethylene pipe liner followed by addition of grout between the outside of the liner and the inside of the old pipe, and 2. placement of concrete across the corroded section at the invert of the culvert. While used for more than a decade, both techniques rely in part on experience-based design or specifications, rather than analysis models that permit design of the Portland cement-based components (the grout and reinforced concrete).

This project featured testing of these structures using the GeoEngineering Laboratory at Queen's—unique facilities that permit construction and testing of prototype scale culverts under earth and surface loads. In each case, circular or elliptical corrugated steel pipes were buried in the West test pit, with responses then measured under single or tandem axle loadings defined in the Canadian Highway Bridge Design Code. The structures were then rehabilitated—the two 0.9m diameter circular pipes repaired with high density polyethylene slip liners, and a 1.6m span ellipse repaired using the concrete paving across the corroded invert as specified by standard Ohio DOT construction practices.

Different Portland cement grouts were examined for sealing the annulus between the liner and the steel culvert—low density aerated grout, and conventional high density grouts. The aerated grout had compressive strength < 2MPa, and experienced extensive shear fractures around grout-liner interface, and through the grout annulus. In contrast, the dense grout had much higher (>10MPa) strength, and had ultimate limit state controlled by tensile fractures at crown, springlines and invert.

Paving of the corroded steel at the base of the culvert had strength limit controlled by bending moments and fracture on the tensile face of the lightly reinforced comcrete

Polyethylene slip liners installed with low density (upper) and high density (middle) grout; fracture in paved invert (lower).

SUSTAINABILITY RATING SYSTEM FOR CULVERT REPLACEMENT AND REHABILITATION

Working with industry collaborators Drs Dicksen Tanzil and Michael Maher, a culvert rehabilitation module was developed for Goldset, a decision support tool from Golder Associates that incorporates sustainability into decisions for civil and environmental engineering projects. The module considers the effect of a range of social, economic, technical and environmental factors on culvert repair or replacement decisions. Case studies on deteriorated concrete and corrugated steel culverts considered options like cut and cover replacement, cured in place pipe lining, spray-on cementitious lining, and grouted slip liners. In each case, the benefits of trenchless rehabilitation were clear, compared to conventional excavation and replacement.

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