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CALEB REGIER, MASC (2015)

INVESTIGATION OF THE FAILURE MECHANISMS OF INTACT AND DETERIORATED CULVERTS

RESEARCH SUMMARY

THREE CORRODED AND ONE INTACT SAMPLE OF CIRCULAR PIPE TESTED IN THE GEOENGINEERING LABORATORY AT QUEEN'S

IMPRESSED CURRENT USED TO ACCELERATE CORROSION IN CORRUGATED STEEL PIPE SAMPLES

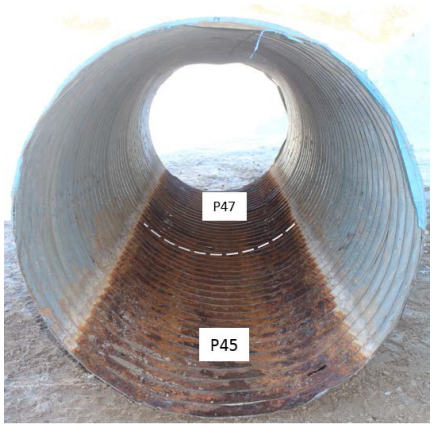
CIRCULAR CULVERT RESPONSE EXAMINED AT TWO BURIAL DEPTHS AND UNDER SINGLE AXLE LOAD

HAUNCH CORROSION CHANGES STRENGTH LIMIT STATE

SERVICE AND STRENGTH TESTS ALSO PERFORMED ON ELLIPTICAL CULVERT, REVEALING FLEXURAL FAILURE

Engineers managing the millions of deteriorated metal culverts and storm sewers across North America need to establish 'How much deterioration is too much deterioration' so safe and economic decisions can be made regarding their repair and replacement. Caleb Regier's MASc project involved burying circular and elliptical steel culverts in the West pit of the GeoEngineering Laboratory at Queen's, and measuring their performance under standard service loads and up to ultimate strength limits.

First, samples were instrumented using optical fibres, conventional strain gages, linear potentiometers and targets for digital image analysis, and performance during burial was monitored. Using the lab's servo-controlled testing system and steel loading pads, service loads associated with the standard Ontario CL-625 design truck were applied to the ground surface. Finally, those loads were increased until ultimate limit states were reached.



Pipe sample with 45-47% of wall loss

In all tests on corroded samples, the soil modulus did more to influence the resulting deformations than the level of wall loss. The circular and elliptical pipes experienced yield as a result of bending moments at the crown and shoulders. As loads were then increased, local buckling developed in the steel strips adjacent to perforations at the haunches of the corroded circular pipe samples. Some ultimate strengths fell short of the code requirements, and the failure mechanisms were not those covered by the existing design models used in the Canadian and US codes.

Caleb with one of his circular pipe samples

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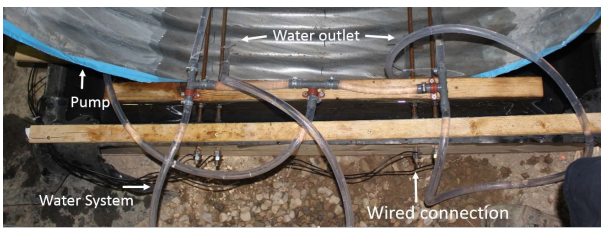
HIGHLIGHTS

- **Part of a Strategic Research Project for the Natural Sciences and Engineering Research Council**
- **Helps establish 'How much deterioration is too much deterioration'**
- **Tests showed how some capacities fell below factored design loads, and how failure modes differed from the design codes**

IMPRESSED CURRENT USED TO CORRODE PIPE SAMPLES

Previous tests on corroded metal culverts have relied on pipes exhumed from the field which has limited the nature and number of samples tested. Working in collaboration with Dr Allan Scott of the University of Canterbury, New Zealand, impressed current procedures were developed to simulate decades of corrosion in a few weeks. Pipes were immersed in a water bath filled up to the pipe haunches. Electrodes running parallel to the haunches concentrated corrosion at that level. Water flow was used to move corrosion products into a collection sump.

First, zinc coating disappeared across the invert and the steel then corroded, particularly at corrugation valleys. Average levels of wall remaining at the haunches ranged from 15 to 50% .



End of pipe bath showing electrodes