The GeoEngineering Centre

Depth Beyond Knowledge™

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VAN THIEN MAI, MASC (2013)

RESEARCH SUMMARY

USE OF AN ULTRASONIC THICKNESS GAGE FOR WALL LOSS MEASUREMENT WAS EVALUATED

TWO DETERIORATED PIPE SAMPLES WERE ASSESSED

PREDICTIONS OF PERFORMANCE WERE MADE USING FINITE ELEMENT ANALYSIS

SAMPLES WERE BURIED AND TESTED AT TWO COVER DEPTHS

ONE STRUCTURE WAS TESTED UP TO ITS ULTIMATE LIMIT STATE

COMPARISON OF MEASUREMENTS WITH CALCULATIONS SHOWED THE INCONSISTENT PERFORMANCE OF DESIGN THEORIES

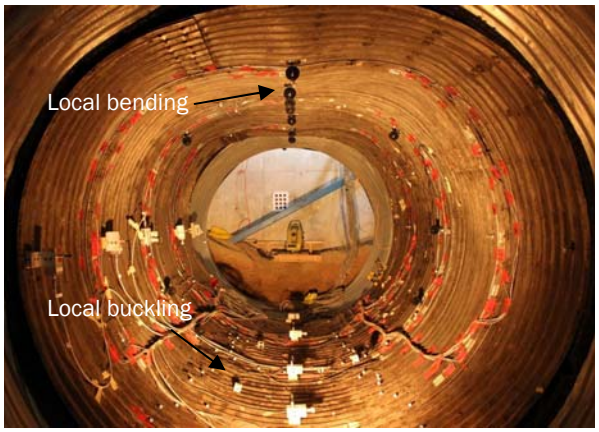
HIGHLIGHTS

- **Involved computer analysis and full-scale testing of deteriorated specimens from MTO**
- **Supported by the Transportation Research Board (US Academy of Sciences)**
- **Provides input for development of new assessment procedures for AASHTO**

ASSESSMENT OF DETERIORATED CORRUGATED STEEL CULVERTS

Millions of deteriorated culverts and storm sewers across North America need evaluation and possibly repair or replacement. Almost all buried pipe investigations have examined new structures, and much still needs to be learned about the strength of deteriorated pipes. This project examined the strength of corroded corrugated metal culverts.
First, a technique was developed to measure the remaining wall thickness in corroded structures. Next, patterns of wall loss were established for two deteriorated test culverts provided by the Ministry of Transportation, Ontario. Finite element calculations were performed to predict the stability of the two deteriorated culverts. Full scale experiments were then undertaken using the facilities in the GeoEngineering Laboratory at Queen's. Each structure was buried in coarse grained backfill, and deformations and strains measured under single wheel pairs and single axle loading. The more heavily deteriorated structure (shown in the photograph) was then tested to collapse, and the failure mode established: local bending across the culvert crown, and local buckling of remnants of steel left between corrosion-induced perforations at the haunches.

Post-test analyses established the poor performance of existing design equations in Canadian and US highway bridge codes, and provides guidance on the use of finite element analysis for stability assessments.



Monitoring system and distress seen in the more heavily deteriorated culvert during ultimate limit state testing

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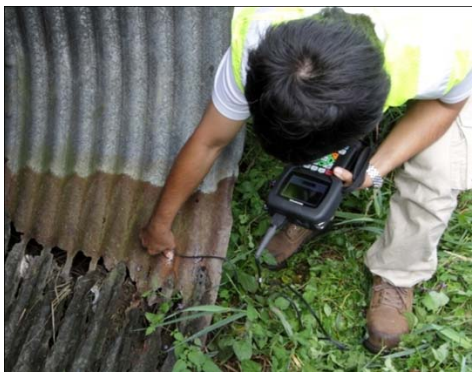
QUANTITATIVE PROCEDURE FOR CULVERT ASSESSMENT

Current culvert assessments often rely on the opinions of the individual inspector regarding the need for repair or replacement. Van Thien Mai developed an objective quantitative assessment procedure based on:

A. characterisation of remaining steel plate thickness using ultrasonic thickness measurements

B. Calculation of deteriorated culvert stability using culvert analysis package CANDE or other finite element programs (e.g. ABAQUS)



Van taking ultrasonic thickness measurements in the field.