

TAMER ELSHIMI, PHD (2011)

RESEARCH SUMMARY

ANALYSIS OF A SERIES OF EXPERIMENTS CONDUCTED BY ANDREA MAK

ABAQUS MODELING INCLUDED MATERIAL AND GEOMETRIC NONLINEARITY

ANALYSIS CAPTURES CULVERT RESPONSE UP TO & BEYOND THE STRENGTH LIMIT

ANALYSIS MODELS CULVERT RESPONSE TO EARTH AND VEHICLE LOADS

ANALYSIS USED EXPLICIT MODELING OF CORRUGATIONS AND THEN ORTHOTROPIC SHELL THEORY

PARAMETRIC STUDIES ON ARCH AND BOX CULVERTS EXAMINED SHAPE, THICKNESS & DEPTH

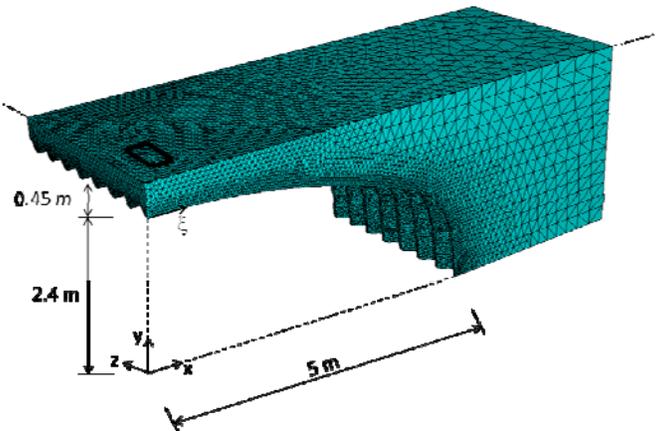
HIGHLIGHTS

- Supported by OGS, NSERC & Armtec who manufacture and sell their culvert product internationally
- Findings now being used by Armtec for design of box and arch structures
- Three journal publications to date, and three others in review
- Now with Thurber Engineering, Edmonton.

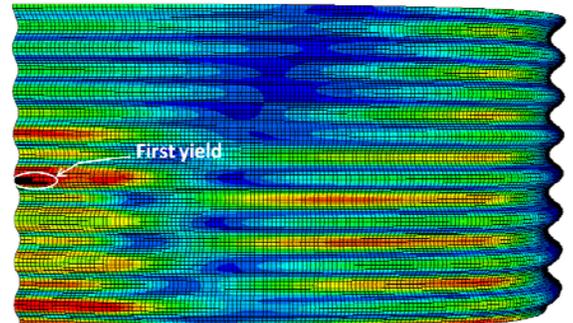
ANALYSIS AND DESIGN OF DEEP CORRUGATED METAL CULVERTS

Large span metal culverts were developed in Canada and the US almost 60 years ago, but the lack of available test facilities has meant that strength measurements were not possible. Now, the next generation of structures developed by Armtec of Guelph Ontario has been tested by Andrea Mak using the unique facilities at Queen's. Tamer Elshimi has used this data to make many new advances in computer modeling of these structures using finite element program ABAQUS. In particular, he developed the first explicit modeling of a large span metal structure of corrugated geometry, including backfilling and surface loading at service loads and up to the ultimate limit state.

The new deep corrugated metal structures develop significant bending moments under earth and vehicle loads, and the analysis has demonstrated how both material and geometric nonlinearity influence the flexural strength. Tamer showed that loading from a pair of trucks is generally the most critical design case, a condition that could not be considered using the earlier generation of 2D analyses. He demonstrated that changes in corrugation geometry influence strength, and his parametric investigation covered box culverts and arch culverts from 6m to 16m span, and from 0.45m to 3m burial depth.



Tamer's 3D analysis using ABAQUS includes modeling of corrugated geometry and burial, capturing stresses at first yield and up to the ultimate limit state.



TESTING AND ANALYSIS PROJECTS SUPPORTED BY ARMTEC.

This project breaks new ground with both testing and analysis. The new testing facility at Queen's permitted experiments on the 10m span culvert. Those experiments, then, allowed development of analyses up to the ultimate limit state, calculations having real authority given the assessment relative to measurements. Armtec supported the two students involved, and also provided some infrastructure funds (primarily supported by the Canada Foundation for Innovation and the Ontario Ministry of Innovation and Technology).

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Culvert testing for tandem axle loads

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