GeoEngineering Centre at Queen's—RMC, Queen's University
Ellis Hall, 58 University Avenue, Kingston ON K7L 3N6, Canada
613 533 3160 info@geoeng.ca

www.geoeng.ca

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# KATRINA MACDOUGALL, MSC (2014)

## RESEARCH SUMMARY

## BEHAVIOUR AND DESIGN OF REINFORCED CONCRETE PIPES

**36 EXPERIMENTS PERFORMED ON SHALLOW BURIED CONCRETE PIPES AT SERVICE LOADS**

**STRAINS MEASURED TO MONITOR MOMENTS UNDER SERVICE LOADS**

**DESIGN MOMENTS EXCEEDED TEST MOMENTS BY SUBSTANTIAL MARGINS IN MOST CASES**

**CONTROLLING LIMIT STATE AT DEEP AND SHALLOW BURIAL- WAS ALWAYS CRACK WIDTH**

**USE OF MODIFIED COMPRESSION FIELD THEORY AND ADJUSTMENT FOR THICK RING BEHAVIOUR RECONCILED THE TWO DESIGN METHODS**

Concrete pipes are designed using two different procedures in North America. The first, Indirect Design, is a simplified approach that uses an empirical 'bedding factor' to relate strength when buried to the strength during 'pipe-only' testing. The second, Direct Design, features estimates of moment, thrust and shear around the pipe circumference and the use of conventional reinforced concrete design approaches to determine steel amounts. This project sought to determine whether Indirect and Direct Design procedures are consistently conservative, and to explain and potentially reconcile discrepancies between the two methods. Firstly, two 0.6 m diameter pipes and two 1.2 m diameter pipes were tested under single wheel pair loading at burial depths of 1.2, 0.6, and 0.3 m. The test pipes did not crack at the applied service load of 110 kN and did not exceed the crack width limit of 0.25mm until between 2.5 and 4 times the service load. One 0.6 m diameter pipe was also tested under simulated deep burial and was found to have cracking load almost 2 times greater than the calculated value. Both methods provided conservative strength estimates for the test pipes. An investigation of the Direct Design procedure found that by considering thick ring theory and the Modified Compression Field Theory with two layers of reinforcement, the required amount of steel from Direct Design could be made to align very closely with Indirect Design.

Additional tests were performed to measure radial earth pressures on a shallow buried 0.6m diameter test pipe using the 'null' sensors of Talesnick. These pressures indicate that lateral soil stresses acting on the pipe springline are much lower than those that arise from use of standard pressure distributions.

*0.6m diameter pipes instrumented and ready for burial in the test pit .*

## HIGHLIGHTS

- **Tests demonstrated the conservatism of both Indirect and Direct Design methods**
- **Recommendations made for changes by AASHTO to reconcile the Direct and Indirect Design Procedures**
- **Katrina is now working for GHD Canada in Toronto**

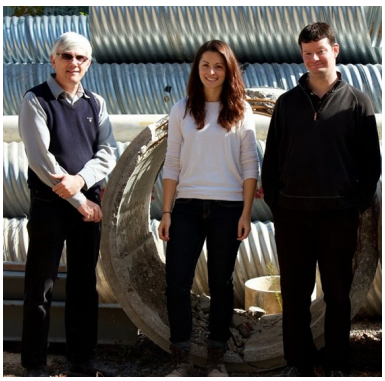
## AASHTO LRFD BRDIGE DESIGN SPECIFICATIONS

This project was funded by the National Cooperative Highway Research Program of the Transportation Research Board (National Academy of Sciences, Washington D.C.) as Project 20-07 Task 316. The project was directed by a panel of highway and other engineers with the specific goal of suggesting changes to the LRFD (Load and Resistance Factor Design) Bridge Design Specifications of the American Association of State Highway and Transportation Officials.

**Project Supervisors:**

**Ian D. Moore, PhD, PEng, FCAE, FEIC**
Professor and Canada Research Chair in Infrastructure Engineering
moore@civil.queensu.ca tel: 613 533 3160

**Neil A, Hoult, PhD, PEng**
Assistant Professor
neil.hoult@civil.queensu.ca tel: 613 533 3436



*Ian, Katrina and Neil outside the Geoengineering Laboratory*