The Geo Engineering Centre

Depth Beyond Knowledge™

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RESEARCH SUMMARY

TESTING OF REINFORCED CONCRETE, THERMOPLASTIC AND CORRUGATED STEEL PIPES

EXPLAINED DEFORMATION PATTERNS AND PIPE TO PIPE INTERACTIONS THROUGH JOINTS

MEASURED JOINT ROTATION CHARACTERISTICS UNDER INTERNAL AND EXTERNAL PRESSURE

USE OF FINITE ELEMENT ANALYSIS TO EXAMINE IMPACT OF JOINT STIFFNESS

ANALYSIS ALSO USED TO CALCULATE STRESS AND STRAIN IN THE BELL AND SPIGOT

PUBLICATIONS INCLUDE THE NCHRP REPORT, AND MATERIAL FOR FIVE JOURNAL ARTICLES

HIGHLIGHTS

- **Seminal study of jointed pipe response to surface loads**
- **Supported by the Transportation Research Board (US Academy of Sciences)**
- **Provides input for development of new design methods for the AASHTO LRFD Bridge Design Specifications**

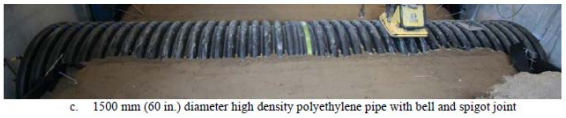
INVESTIGATION OF CULVERT JOINTS EMPLOYING LARGE SCALE TESTS AND NUMERICAL SIMULATIONS

Long term stability of culvert and sewer pipes can depend on successful performance of the joints connecting individual pipe barrels. However, little research has been conducted to determine the expected demands across the joint (the vertical shear force transferred and the rotation or bending moments passed from one pipe to the next). This study involved extensive laboratory testing of reinforced concrete, corrugated steel and thermoplastic pipes to establish behaviour under simulated vehicle load. The action of a single wheel pair was determined to be most critical. The response generating maximum joint rotation was examined with wheels located over the joint, and other locations were then examined which generate shear force across the joint. Data for the different pipe systems at two different burial depths demonstrated the nature of joint behaviour in the rigid (reinforced concrete) and flexible (corrugated steel and thermoplastic) culverts.

Finite element analysis was then used to examine behaviour of the 0.6m (24 in.) reinforced concrete pipe. Techniques for modeling the rubber gasket were used to establish that gasket stiffness has little impact on longitudinal deformations. Calculations for deformations along the pipe and strains in the bell (female) and spigot (male) components of the joint were compared to measurements, to establish the effectiveness of the calculation procedures.

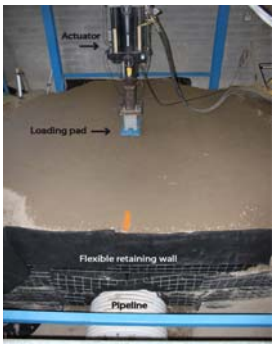
a. 600 mm (24 in.) diameter reinforced concrete pipe with gasketed bell and spigot joint

b. 900 mm (36 in.) diameter corrugated steel pipe with unsealed band joint



c. 1500 mm (60 in.) diameter high density polyethylene pipe with bell and spigot joint

Reinforced concrete, corrugated steel and high density polyethylene pipe culverts prior to burial; joints are located midway across the test pit.



Buried PVC pipe with gasketed bell and spigot joint being tested under a simulated wheel pair using the large actuator and reaction frame at the GeoEngineering Laboratory at Queen's .

SIMPLIFIED KINEMATICS USED TO DEVELOP DESIGN EQUATIONS

The test results demonstrated how concrete pipes behave like rigid links connected by hinges (at the joints), and that response can conservatively be simplified by considering two pipes connected by a single joint. The experiments performed on flexible pipes showed that response to surface loads was localized in the vicinity of the joint, and that conservative approximations could be developed considering two very long flexible pipes connected at a single joint. Simplified design equations for shear force, rotation and moment across culvert joints, resulting from vehicle and earth loads have since been developed.

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David conducting one of his tests