Reinforced Concrete Microtunnelling Pipe

Designed for Project Conditions and MTBM Machines

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TRENCHLESS TECHNOLOGY ROADSHOW
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REINFORCED CONCRETE MICROTUNNELLING PIPE

- Design Requirements for Pipe
- Design Methodologies
- Design Challenges
- Consultant/Contractor/Manufacturer Responsibilities
- More Information
MICROTUNNELLING

- Non manned
- Laser guided
- Remote controlled
- Continuous – from entry shaft to exit shaft
- Pipe jacking

Image courtesy Herrenknecht
PIPE DESIGN CONSIDERATIONS

- Designed for MTBM machine and site conditions
- In Canada – European and American MTBMs

OD to suit MTBM equipment
ID to suit job requirements
Lubrication pipes (with ports) required
Interjack station / pipes may be required

Pipe wall thickness determines
STANDARDS FOR PIPE DESIGN

• Typically Canada follows U.S. in pipe standards
• No U.S. Standard

Pipe should be designed by pipe manufacturer
BASIS FOR PIPE DESIGN

- CAN/CSA A257.2-09 - Reinforced circular concrete culvert, storm drain, sewer pipe and fittings
- ASCE 27-00 – Standard Practice for Direct Design of Precast Concrete Pipe For Jacking in Trenchless Construction
- ACPA Design Data 13 – Jacking Concrete Pipe
- CAN/CSA-S6-06, Canadian Highway Bridge Design Code
DESIGN REQUIREMENTS

**Short Term – During Microtunnelling**
- Pipe must resist concentric jacking force necessary to overcome soil resistance
- Joint must resist stresses from eccentric jacking force at angular change of alignment (within established limits)

**Long Term – Installation**
- Dead loads – earth load
- Live loads, groundwater, internal pressure
DESIGN REQUIREMENTS

Infrastructure Owner/Consultant
- Use of pipeline
- Pipe internal diameter
- Plan/profile drawings
- Installation requirements
- Geotechnical baseline report

Matrix of Responsibility varies depending on job, companies and people involved

Microtunnelling Contractor
- Maximum jacking force
- Angular change in alignment
- Details of jacking frame
- Provisions for groundwater
- Maximum intended drive length- jacking stations, lubrication procedure
DESIGN METHODOLOGIES

Indirect Method

Direct Method

- Arching Coefficients, Heger
- Uniform Load System, Paris
- Radial Load System, Olander

Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction (27-00)

American Society of Civil Engineers

Standards ASCE 27-00

INDIRECT METHOD

1. Determine un-factored loads using Marston-Spangler (Principles)
2. Define the bedding factor and design Three-Edge-Bearing (TEB) load by relating D-Load to actual loads
3. Select pipe class in terms of D-Load that produces certain performance limits in the pipe
SPECIFICATION OF PIPE CLASS

• Design TEB strength for different standard diameters in CSA A257.2-09
• Interpreted to a D Load
  • In plant testing to verify D Load - (TEB) test
• Relates to pipe class via CSA A257.2-09
  • Pipe class determines reinforcement/manufacturing

Higher pipe class ≠ stronger jacking pipe
Axial strength is important for microtunnelling
DIRECT METHOD

• ASCE 27-00
• Consider combined effect of all loads
  • pipe weight, earth load, weight of fluid inside pipe, external and internal fluid pressure, live loads (highway, aircraft, railway)
• Determine flexure, crack control, radial tension, diagonal tension
• Then determine required reinforcement for pipe manufacture

Pipe is designed exactly to suit application
JACKING FORCES

Jacking forces < Limits of pipe with a safety factor

Pipe design

• Maximize face area to take jacking forces
• Epoxy coated steel band on jacking end

Maintaining tolerance on OD is important

• Ensures consistent overcut
• “Squareness” of the pipe
DIRECT DESIGN – AXIAL LOADS

• ASCE
• Design for perfect situation
  • Uniform (concentric) distribution of force
• Design for a real microtunnelling operation
  • Eccentric distribution
    • Zero stress at one edge of joint, maximum stress at opposite edge
  • Partial linear distribution
    • Zero stress at an intermediate point on the axis, maximum stress at opposite edge
JOINT DEFLECTION vs JACKING FORCE

No joint separation. Full contact on bearing. Surface is maintained.
CHALLENGES - CURVES

- Driving curves causes angular displacement at pipe joints

MTBM alignment control system
- Monitor angular deflection of each pipe within design limits
- Information tracked and available to infrastructure owner/consultant
CHALLENGES – INTERJACKS

IF

Actual jacking force required > allowable thrust force on joint

• Intermediate Jacking Stations (Interjacks) required
• Need must be determined prior to manufacturing pipe
• Pipe design and manufacturing are affected by use of Interjacks
CHALLENGES - INTERJACKS

Separated

Assembled
CHALLENGES

Settlement
• Needs to be controlled during tunnelling
• Grouting and maintaining the annulus are key
• If not it can result in deflection of the pipe joint

Ground Water Table
• Negative pressure
• Affects design of joint
• Affects type of gasket used
TYPES OF JOINTS

• Standard butt joint (most common)
• Existing pipe joint designs can be adopted for microtunnelling
  • CAN/CSA A257, ASTM C76, C361, AWWA C302
• Various types of gaskets can be used
  • Vary type of gasket (Profile, O-Ring)
  • Modify pipe joint to hold gasket
## NOTABLE MICROTUNNELLING JOBS

<table>
<thead>
<tr>
<th>Job</th>
<th>Pipe ID</th>
<th>Details</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>Region A</td>
<td>325 mm</td>
<td>Two 122 in (3.05 m) diameter sewer lines laid, 3.0 m deep, 6.5 m length</td>
<td>Nov 2021</td>
</tr>
<tr>
<td>Hyde Park sewage outfall</td>
<td>250 mm</td>
<td>250 m long 122 mm DI pipe (lap joint), 3.0 m deep, 3.0 m length, 250 m in line with existing and horizontal route combining areas and adjacent 300 mm dia. lines 3.0 m deep</td>
<td>Aug 2022</td>
</tr>
<tr>
<td>Central office connect</td>
<td>250 mm</td>
<td>Two 122 mm (3.05 m) diameter sewer lines laid, 3.0 m deep, 3.0 m length</td>
<td>Jul 2021</td>
</tr>
<tr>
<td>High Park sewage outfall</td>
<td>250 mm</td>
<td>250 m long 122 mm DI pipe (lap joint), 3.0 m deep, 3.0 m length, 250 m in line with existing and horizontal route combining areas and adjacent 300 mm dia. lines 3.0 m deep</td>
<td>Jul 2021</td>
</tr>
<tr>
<td>Felixstowe sewage outfall</td>
<td>305 mm</td>
<td>122 mm (122 mm) soil pipe (lap joint), 2.0 m deep, 2.0 m length, 250 m in line with existing and horizontal route combining areas and adjacent 300 mm dia. lines 2.0 m deep</td>
<td>June 2021</td>
</tr>
<tr>
<td>Winter Hill sewage outfall</td>
<td>305 mm</td>
<td>122 mm (122 mm) soil pipe (lap joint), 2.0 m deep, 2.0 m length, 250 m in line with existing and horizontal route combining areas and adjacent 300 mm dia. lines 2.0 m deep</td>
<td>June 2021</td>
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MORE INFORMATION

Microtunnelling Brochure

To start the discussion about a specific microtunnelling project
microtunnelling@munroltd.com