

# MAINTENANCE & REHABILITATION OF CULVERTS

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## Introduction

- Widely used, started in 1950
  - low cost alternative to bridges
  - road system expansion in 60s and 70s
- Installed by road builders
  - local road authorities
  - district forces (day labour)
- Designs by Bridge Engineering then Regional Bridge staff, now consultants

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## Technical Developments

- Early history - many problems
  - spectacular uplift failures
  - undersized
  - deformation and cracking
- Need for quality backfill and compaction not recognized
- Importance of end treatments

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## Culvert Inspection

- Regular inspection initiated in mid-80s
  - before major problems or failures reported
- inspection provides early detection of changes
- most defects develop slowly
- poor backfill often detected at first inspection
- As constructed records shape at ends, quarterpoints and middle

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## Structural Problems

- Include:
  - Deformation
  - Cracked seams
  - Corrosion
- Usual causes
  - poor quality backfill
  - frozen backfill
  - poor compaction
  - poorly prepared foundation
  - corrosive environment
  - piping

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## Structural Problems Deformation

- Heaving floors
- Bulging walls
- Sagging roof
- Severity measured as percent of design shape
- Contributing factors
  - backfill low shear strength
  - culvert material low bending strength
  - load carried in ring compression and soil-steel interaction

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## Structural Problems Cracked Seams

- Primary cause is deformations
  - sometimes deformations small; 5%
  - may occur at one or more seams
- Contributing factors
  - incorrect laps
  - over torquing bolts
  - improperly curved plate
- Severity measure
  - number of seams cracked
  - location of seams
  - remaining steel between cracks

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## Structural Problems Corrosion

- Corrosion
  - electrochemical process that converts metal to natural state
- Environmental requirements
  - differences in potential
  - electrolyte
  - Oxygen
- Corrosion types
  - electrolytic
  - galvanic
- Severity measure
  - percent rust pitting or perforation
  - static potential
    - 950 mV galvanizing is good
    - 800 mV galvanizing is failing

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### Waterside Corrosion on Culvert Floor

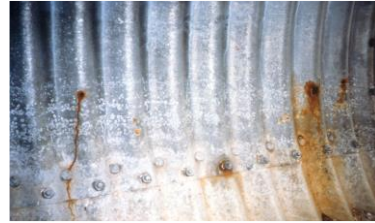


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### Soilside Corrosion Damage



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### Corrosion

- Electrolytic corrosion
  - caused by external stray currents
  - other cathodic systems
  - overhead power lines
- Galvanic corrosion
  - materials of different potential in an electrolyte
  - impurities in metal
  - differences in coatings
  - surface defects
  - moist soil good electrolyte
  - generates own current

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### Electrolytic Corrosion Mechanism

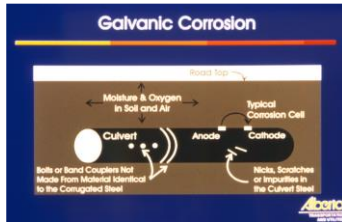


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## Galvanic Corrosion Mechanism



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## Repairs and Maintenance Methods

- Monitoring
- Strutting
- Liners
- Crack repairs
- Cathodic protection

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## Monitoring

- Should be recommended sparingly – only when measurable (Section 13.9.1.2)
- First option, low cost
  - structure may stabilize – especially deflections
- Provides ongoing record
  - mark ends of cracks
  - measure magnitude and location of deformations
  - establish reference points
  - photographs

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## Strutting

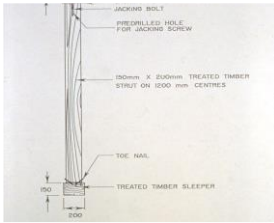
- Oldest, often cheapest method
- Effective for extreme distress
- Not suitable for drift and ice locations
- Components
  - vertical struts between sleepers
  - cut to length, jacked in place
  - timber or steel
- Life ~25 years for timber – maybe longer for steel struts

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### Timber Strut with Adjustable Turn-screw

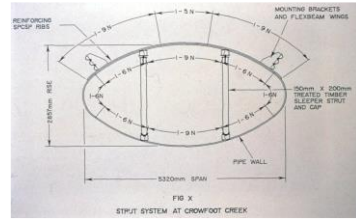


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### Strut Layout for Horizontal Ellipse Culvert

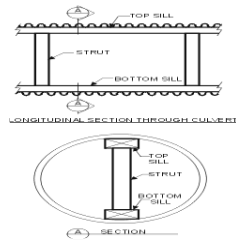


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### Timber Strutting of Metal Culverts



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### Installing Struts



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### Completed Installation



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### TT Struts and Braces



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### Horizontal TT Strut



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### Steel Struts



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## Liners

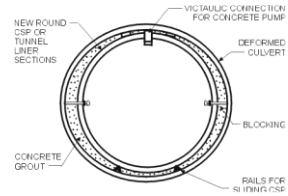
- Used when culvert cracked or corroded
- Reduces hydraulic capacity
- Increases velocities, back water
- Not suitable for large deformations
- Life 30 to 40 years

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## Culvert Liners



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## Liner Types

- CSP culvert
  - 1.5m to 3.0m culverts
- SPCSP
  - larger than 3.0m culverts
  - limited length
- Tunnel liner
  - large culverts and long length
- Smooth wall pipe
  - Usually <1.5 m diameter culverts

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## Installing CSP Liner into Existing SPCSP Culvert



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**Internal Bracing Installed Prior to Grouting**



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**Installing Steel Headwalls at Ends of Pipe to contain grout**



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**Grout / transit mix installed through holes cut into roof of original pipe.**



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**Winch at Outlet to pull new CSP liner into pipe**



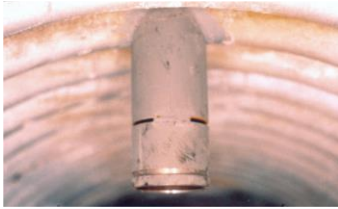
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### Victaulic Connector for Concrete Pump



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### Installing Tunnel Liner Inside Culvert



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### Tunnel Liner Ready for Grouting



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### Smooth Wall Steel Pipe Liner in CSP



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## Concrete Floors

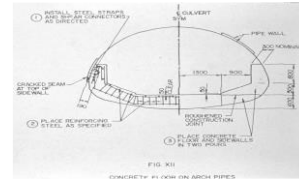
- Repair severe perforations of invert
- Reinforce cracked seams and sidewall deformation of arch culverts
- Reduces hydraulic capacity

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## Details of Concrete Floor for SPCSP Arch



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## Reinforcing Steel Arrangement



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## Concrete Floor Cast

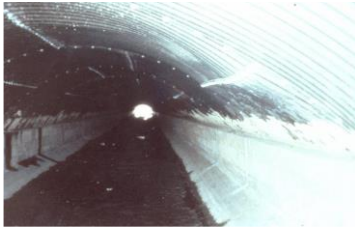


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### Finished Floor and Ponywall



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### Reinforcing Steel Arrangement – Wire mesh



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### Pouring Concrete Floor



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### Ends of Pipe Targed off to heat.



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## Crack Repair Methods

- stop drilling crack ends
- welding cracks
- reinforcing plates
  - welded
  - Bolted
- reinforced concrete
  - arch culverts
- shotcrete

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## Shotcrete Reinforcing

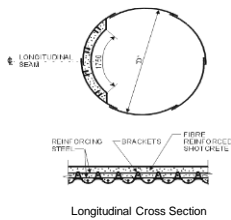
- Preferred method for repairing cracks
- Stiffens joint and transfers ring compression
- sprayed over shear connectors and rebar
- 20-year life
- Not suitable for:
  - small cracks
  - cracks on both sides
  - severe corrosion
  - large deformations

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## Longitudinal Seam Reinforcing



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## Pump and Mixer for Prewetting



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### Detail of Reinforcing and Shear Connectors

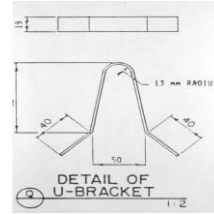


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### U-bracket Shear Connector



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### Sandblast Equipment



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### Heaters



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### Reinforcing and Shear Connectors Ready for Shooting

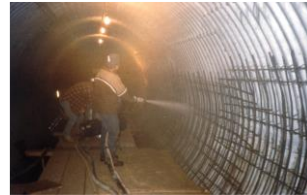


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### Shooting Concrete Mix



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### Completed Crack Reinforcing Beam



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### Completed Crack Reinforcing Beam



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## Cathodic Protection

- Prevents corrosion
  - impressed uniform potential
  - anode sacrificed to protect structure
  - soil side corrosion only
- System types
  - impressed current system
  - passive system

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## Cathodic Protection

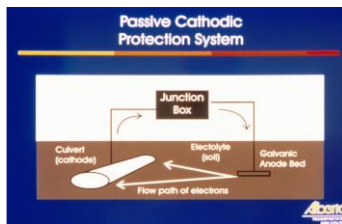
- Impressed current system
  - 20 to 60 volts and 4 to 16 amps
  - available power on site, 120/240 AC
  - power supply, anode bed, electrolyte
  - life - 15 to 25 years
- Passive system
  - dissimilar metals create current and potential
  - many magnesium anodes sacrifice to protect structure
  - 1 to 2 amps and 1 to 2 volts
  - life - 15 to 25 years

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## Passive Cathodic Protection

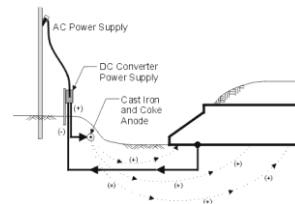


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## Culvert Cathodic Protection



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### Anodes



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### Anode Cross-section



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### Downstream Restoration



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### Jacking Culvert Under Highway



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### Environment Controls - Siltation Fence



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Questions?

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