



Maintenance and Rehabilitation of Culverts

Maintenance and Rehabilitation of Culverts




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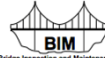
Maintenance and Rehabilitation of Culverts

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
- Designs by Bridge Engineering then Regional Bridge staff




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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 or under 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






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Waterside Corrosion on Culvert Floor






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Soil-Side Corrosion Damage






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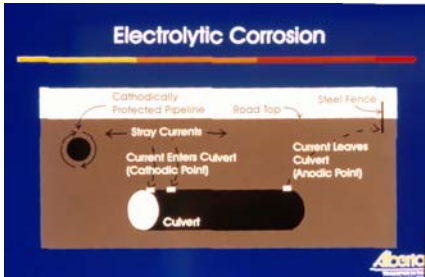
Corrosion



- 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

Galvanic Corrosion

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Repair and Maintenance

- Monitoring
- Strutting
- Liners
- Crack repairs
- Cathodic protection
- Concrete Floors
- Extensions
- Scour/Piping Repairs

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Monitoring

- First option, low cost
 - structure may stabilize
 - Review BIM history
- 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

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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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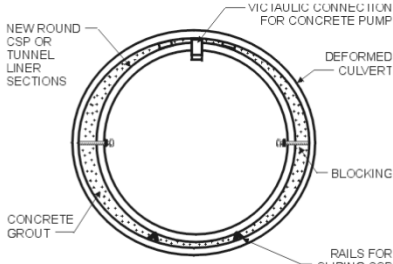
Liners



- Used when culvert cracked or corroded
- Reduces hydraulic capacity
- May increase velocities, back water
- Not suitable for large deformations
- Life 30 to 60 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
 - Generally less than 1.5m culverts


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Installing CSP Liner into Existing SPCSP Culvert




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Pulling Assembled SPCSP into Concrete Box Culvert



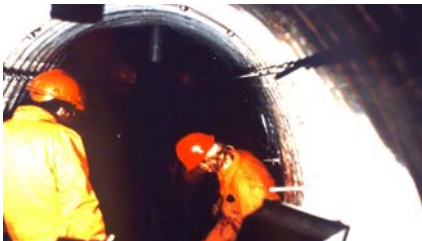
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SPCSP Liner Inside Concrete Box




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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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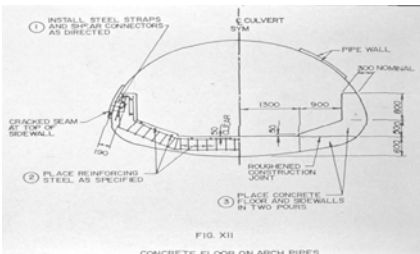
Concrete Floors



- 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 Casts



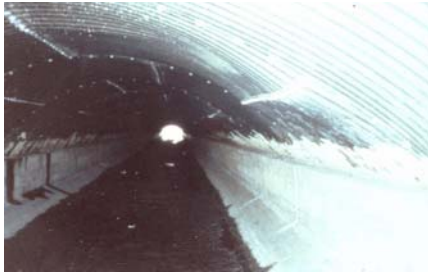
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Floor and Sidewall in Place



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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
- Not suitable for:
 - small cracks
 - severe corrosion
 - large deformations



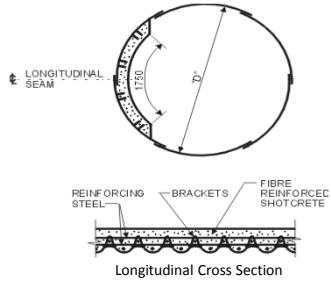
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Longitudinal Seam Reinforcing




Longitudinal Cross Section




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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

DETAIL OF U-BRACKET
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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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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

Passive Cathodic Protection System

Junction Box

Culvert (cathode)

Electrolyte (soil)

Galvanic Anode Bed

Flow path of electrons

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Impressed Current System

AC Power Supply

DC Converter Power Supply

Cast Iron and Coke Anode

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Anodes

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Anode in Trench


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Culvert Extension




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Cut-off Wall - Piping




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Downstream Restoration



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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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