

E.L. Robinson Engineering of Ohio Co.

August 30, 2018

Basics of Culvert Durability

Kevin White

National Hydraulic Engineering Conference
August 28 – 30, 2018



Basics of Culvert Durability

- Outline
- Durability Concepts
- Metal Culverts
- Concrete Culverts
- Plastic Culverts
- Conclusion



E.L. ROBINSON
ENGINEERING

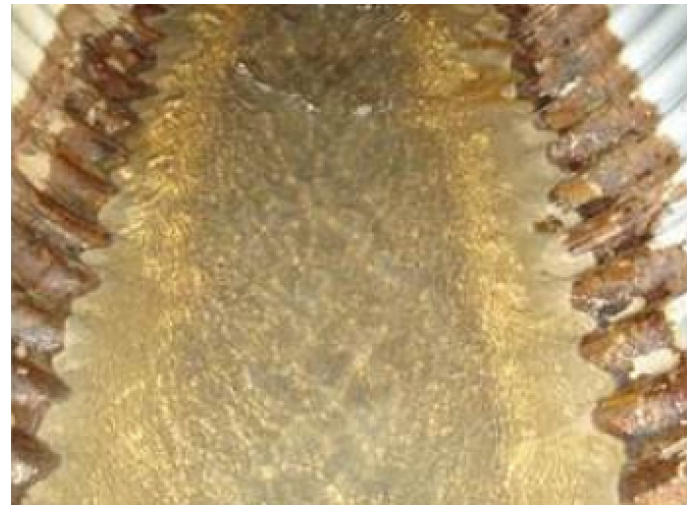
Durability Concepts

- Culvert Durability
 - Resistance to environmental degradation
 - Corrosion
 - Abrasion
 - Thermoplastic degradation
 - Other factors not considered herein
 - Joints
 - Structural
 - Freeze-thaw
 - Installation



Durability Concepts

- Corrosion
 - Acids
 - Less than 5.5 is strongly acidic
 - Greater than 8.5 strongly alkaline



E.L. ROBINSON
ENGINEERING

Durability Concepts

- Corrosion
 - Resistivity
 - Measure of ability to conduct electrical current
 - Inverse of Conductivity

Durability Concepts

- Corrosion
 - Chlorides
 - Chloride ions decrease resistivity

Durability Concepts

- Corrosion
 - Sulfates
 - High sulfates can lower pH
 - Sulfates can deteriorate concrete by reacting with lime in cement to create calcium sulfate



Durability Concepts

- Corrosion
 - Microbial
 - Many different processes
 - Typically associated with standing water, high ground water, or very high humidity



Durability Concepts

- Abrasion

- Progressive section loss
 - Almost always evidenced in culvert invert
 - High stream velocities
 - High bedload
- CalTrans has extensive information on abrasion



Durability Concepts

- CalTrans Abrasion

Level of Abrasion	Description
Level 1	Virtually no bed load with velocities less than 5 ft./s (1.5 m/s); Where there are increased velocities with no bed load (e.g. urban storm drain systems or culverts < 30" (0.76 m) dia.); significantly higher velocities may be applicable to Level 1.
Level 2	Bed loads of sand, silts, or clays regardless of volume. Velocities > 3 ft./s (0.9 m/s) and < 8 ft./s (2.4 m/s). Where there are increased velocities with minor bed load volumes (e.g. urban storm drain systems or culverts < 30" (0.76 m) dia.); Significantly higher velocities may be applicable to Level 2.
Level 3	Moderate bed load volumes of sands and gravels (1.5" (38 mm) max); Velocities > 5 ft./s (1.5 m/s) and < 8 ft./s (2.4 m/s); Where there are increased velocities with minor bed load volumes < 1.5" (38 mm) (e.g. storm drain systems or culverts < 30" (0.76 m) dia.), higher velocities may be applicable to Level 3.
Level 4	Small to moderate bed load volumes of sands, gravels, and/or small cobbles/rocks with maximum stone sizes up to about 6 in (150 mm); Velocities > 8 ft./s (2.4 m/s) and < 12 ft./s (3.7 m/s).
Level 5	Moderate bed load volumes of sands, gravels, and/or small cobbles with maximum stone sizes up to about 6 in (150 mm); For larger stone sizes within this velocity range, see Level 6. Velocities > 12 ft./s (3.7 m/s) and < 15 ft./s (4.6 m/s).
Level 6	Heavy bed load volumes of sands, gravel and rocks, with stone sizes 6 in (150 mm) or larger. Velocities > 12 ft./s (3.7 m/s) and < 20 ft./s (6.1 m/s); Or Heavy bed load volumes of sands, gravel and small cobbles, with stone sizes up to about 6 in (150 mm); Velocities > 15 ft./s (4.6 m/s) and < 20 ft./s (6.1 m/s); Very limited data on abrasion resistance for velocities > 20 ft./s (6.1 m/s) – contact District Hydraulics Branch.

Durability Concepts

- Combined Abrasion and Corrosion
 - Corrosive layer formed and then abraded away
 - Resultant section loss can be many times greater than addition of each individual processes



Durability Concepts

- Thermoplastic Degradation
 - Oxidation
 - Exhaustion on anti-oxidant packages leads to brittleness and cracking
 - Slow-crack growth
 - Formation of cracks under sustained low-stress
 - UV degradation

Metal Culverts

- Steel
 - Protective Coatings
 - Galvanizing
 - Aluminizing
 - Bituminous coating
 - Polymer coating
 - Invert paving
- Aluminum



Metal Culverts

- Steel
 - pH between 5.5 – 8.5
 - Resistivity $> 2000 - 5000 \Omega\text{-cm}$
 - Not recommended for highly abrasive sites unless protective coating provided
- Aluminum
 - pH between 5.5 – 8.5
 - Resistivity $> 1500 \Omega\text{-cm}$
 - Not recommended for highly abrasive sites

Concrete Culverts

- pH < 5
 - Use special concrete mix with high alkalinity
 - Add sacrificial concrete cover
 - Coatings
- Generally abrasion resistant
- Sulfates > 0.5%
 - Use special cements (Type V cement)

Concrete Culverts

- Be cautious of corrosion of exposed reinforcing
 - Chlorides > 500 ppm with cracks > 0.02 in.

Plastic Culverts

- Generally inert to corrosion
- Resistance to very high abrasion is not well documented
- Oxidation
 - Currently handled through material standards
- Slow-crack resistance
 - Currently handled through material standards

Plastic Culverts

- UV degradation
 - Polymer additives generally protect from UV
 - Do not recommend long-term sun exposure
 - Use end walls



Fire

- Most pipe types will experience some damage during intense fire
- In locations of forest or brush fires
 - Bituminous coated steel pipes
 - HDPE



Questions/Comments

Presented By:
Kevin White
kwhite@elrobinson.com
614-586-0642