

Optimizing Performance of Zinc Coated Reinforcing Steel in Concrete Structures

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Outline

- The Corrosion Problem
- Batch Galvanized
- Mitigation Solutions
- Zinc in Concrete
- Continuous Galvanized
- Research and Current Projects
- Next Steps



International Zinc Association

- Trade association that represents the interests of the zinc industry

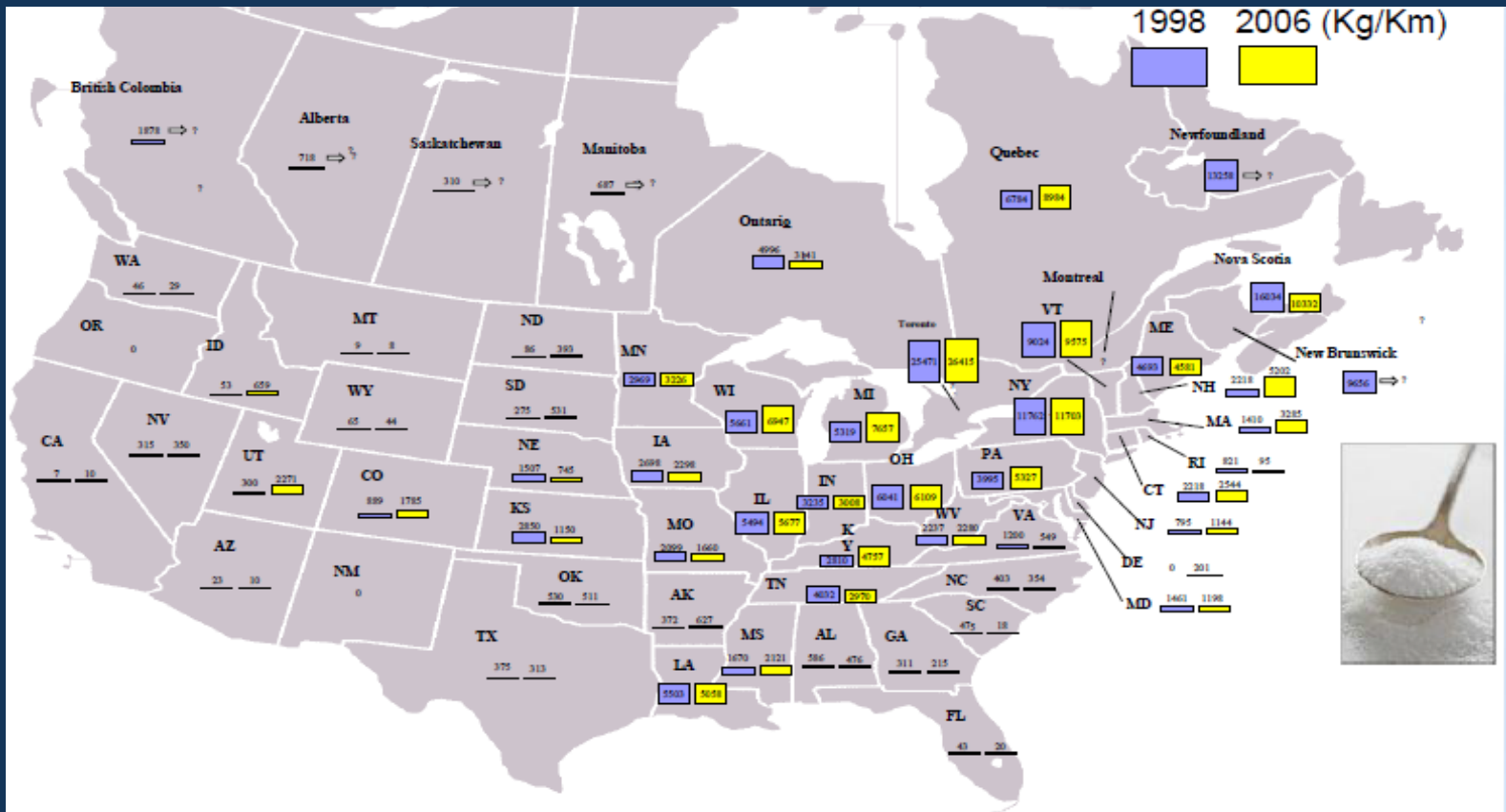


The USA Bridge Problem

- 604000 bridges across the USA
 - 48% state owned
- 2/3 built 26+ years ago
- 50-80% maintenance funds for bridge decks
- 25-30% of corrosion could be eliminated
 - If proper materials are used and maintained



Road Salt in North America



References

-USGS, 1997-2006 salt minerals yearbook. Chart 6-. www.usgs.gov
-http://www.he-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/psl2-lsp2/road_salt_sels_voirie/road_salt_sels_voirie-eng.pdf



Galvanized Reinforcing Steel

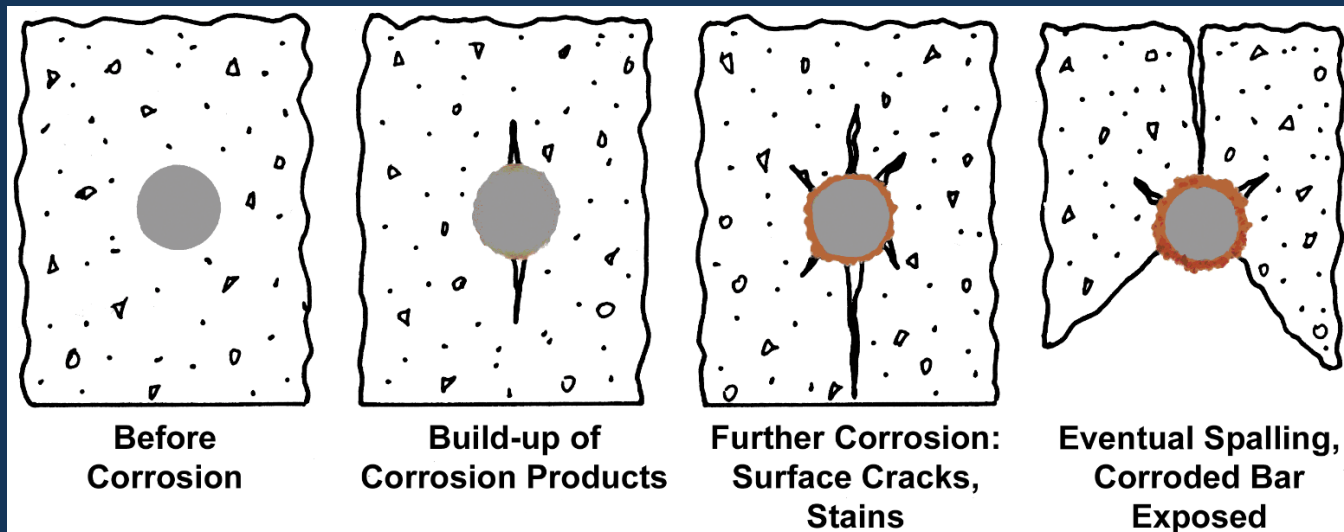


Built in 1995

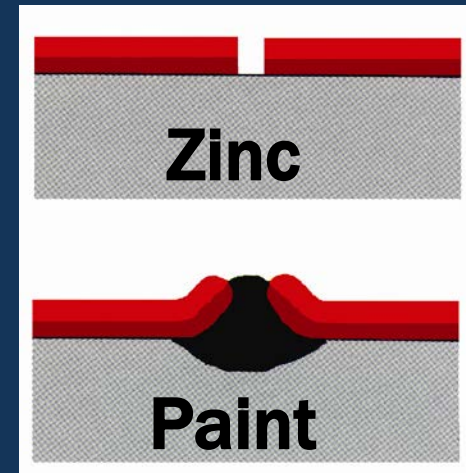
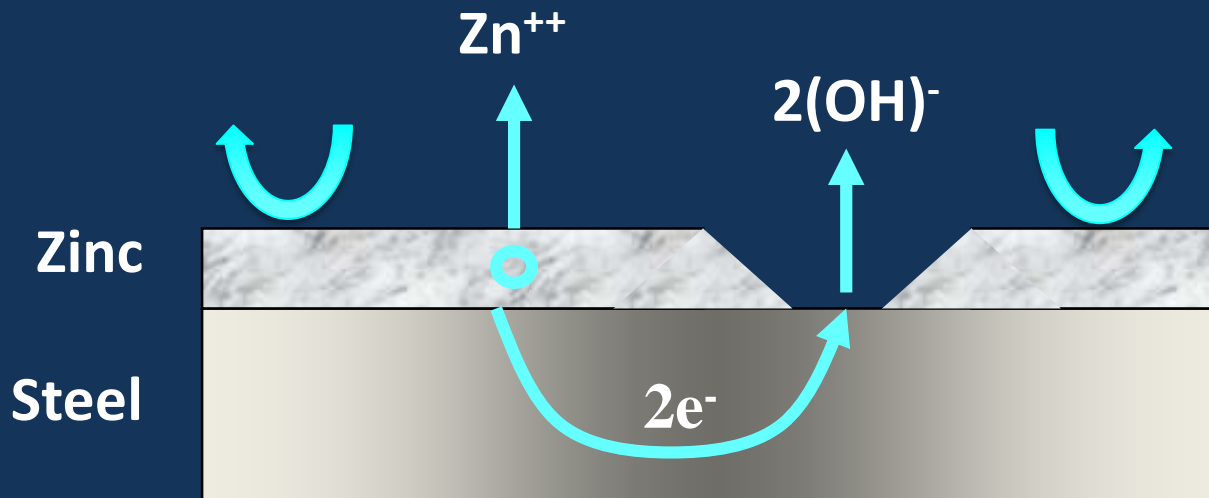
Built in 1990

Corrosion of Black Bar

- In concrete, steel corrosion can cause major deterioration
- Corrosive elements, diffuse through the concrete matrix to reach rebar



Zinc Protection

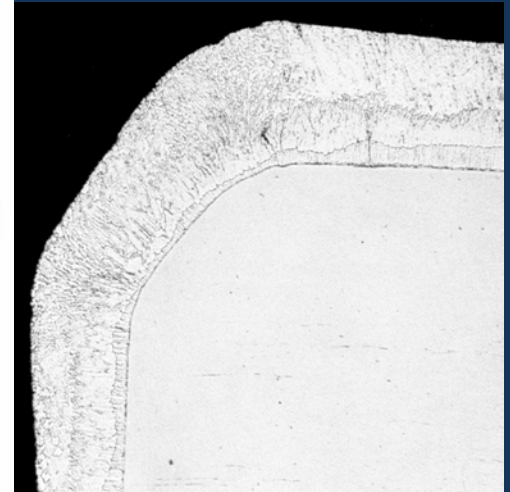
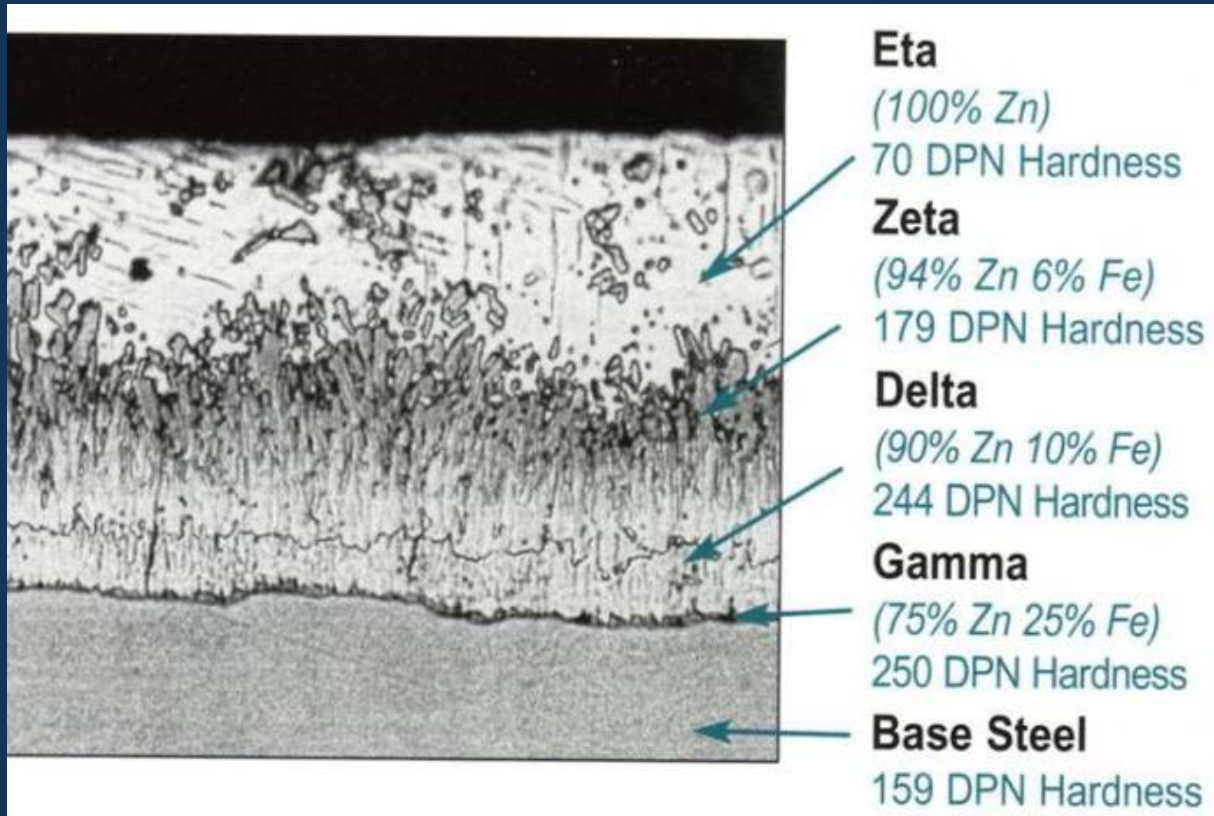


Zinc Protection

- Passivation Reaction Product (CHZ)
- Barrier Coating
- Cathodic Protection
- High Chloride Threshold (2-4x black steel)
- Corrosion Product Migration
 - Concrete Matrix Densification
 - No stress generated at rebar surface
- Low pH Tolerance (Carbonation protection)

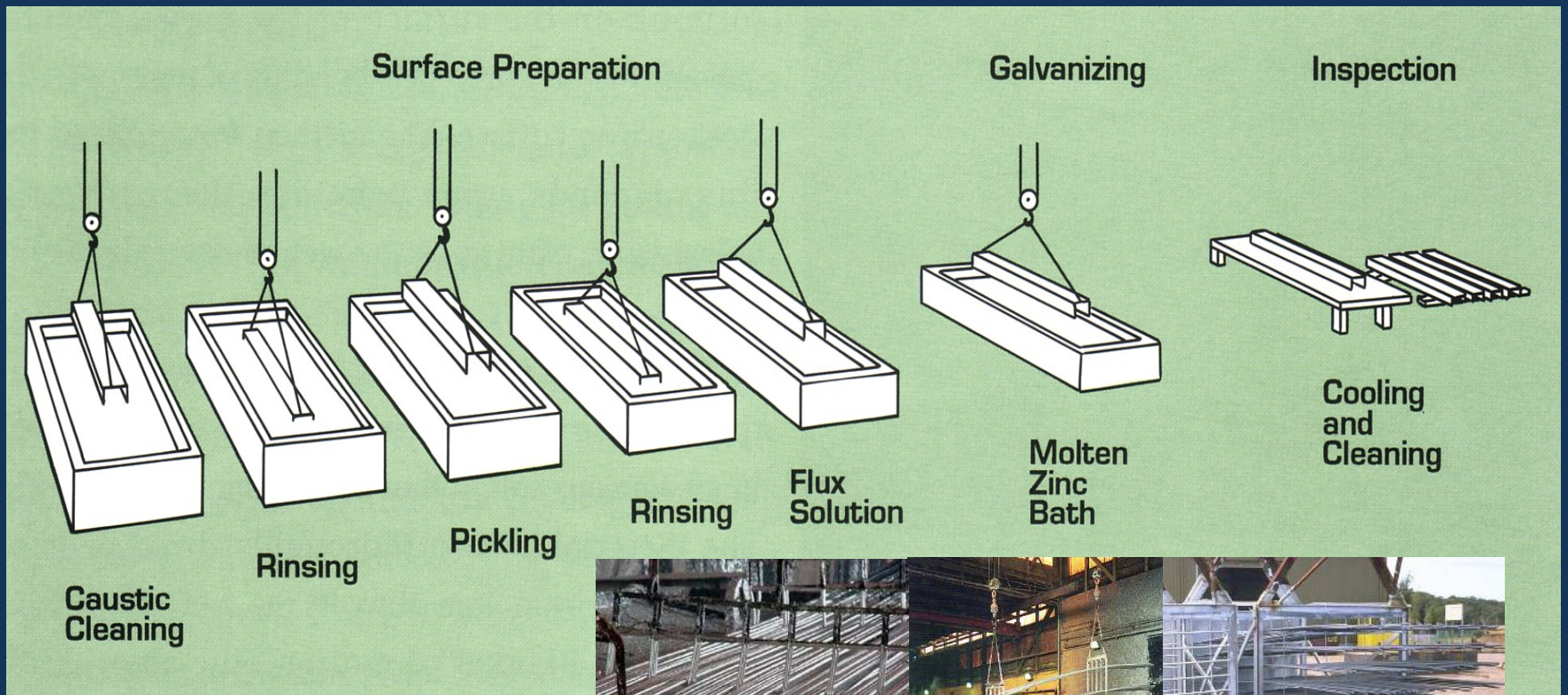


Batch Galvanized Coating



ASTM A767 Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

Batch Galvanized Process



Batch Galvanized Bridges



Boca Chica Bridge, Florida



Tappan Zee Bridge, New York



Curtis Road Bridge, Michigan

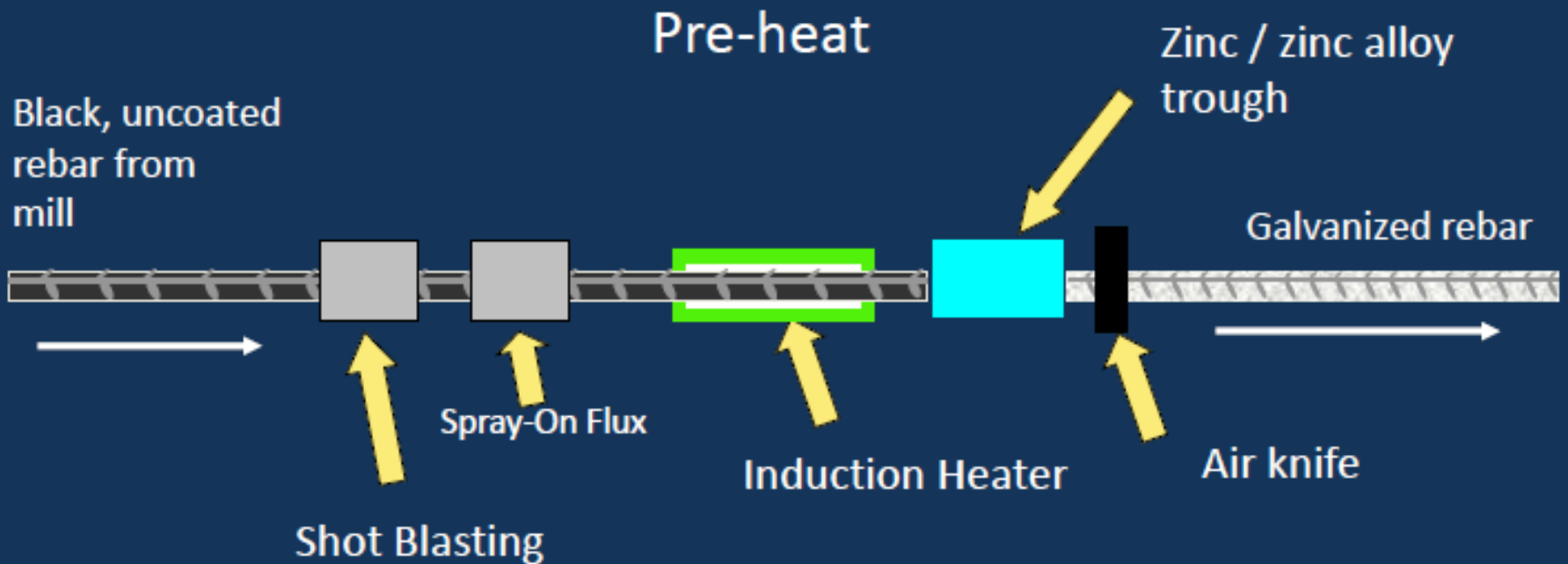


Athens Road Bridge, Pennsylvania

Continuous Galvanized Process

Surface preparation

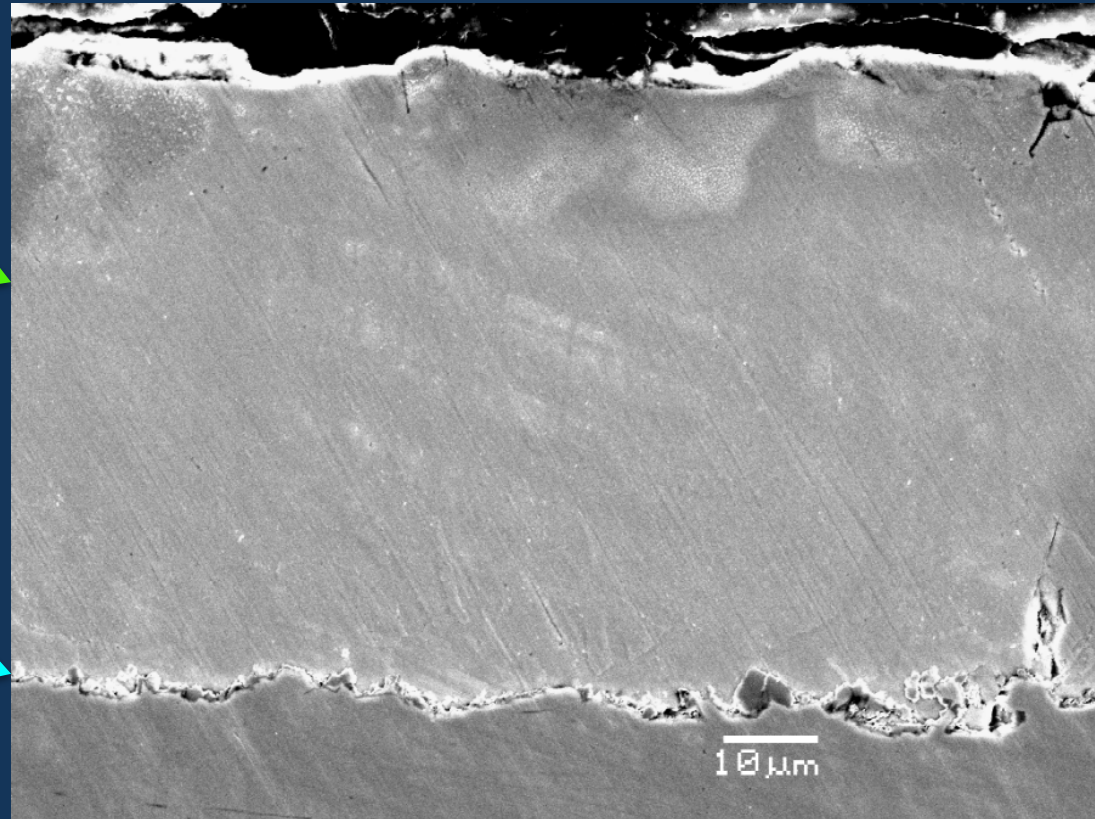
Galvanizing



Continuous Galvanized Coating

Pure Zinc
Layer

Thin
 $\text{Fe}_2\text{Al}_{5-x}\text{Zn}_x$
Layer



ASTM A1094 - Standard Specification for Continuous Hot-Dip Galvanized Steel Bars for Concrete Reinforcement

Formability



Duplex Bar Formability



Continuous Galvanized Rebar

- Durable, Flexible Coating
 - Fabricate after coating
- Pure Zinc
 - Improved corrosion resistance
- Low cost
 - Less material, shipping, weight, etc.



Installing Galvanized Rebar

Same as Black rebar:

- Overlap links
- Handling procedures
- Field Bending Possible

Optional:

- Touch-up field cut ends



Route 66 Bridge



Parsons Precast Steps



Medicine Wheel, McMaster University



AZZ Facility Sandblast Pit



AZZ Facility Sandblast Pit



City of Canton, OH Footbridge



City of Canton, OH Footbridge



City of Canton, OH Footbridge



City of Canton, OH Footbridge



Shenzhen Metro Line No. 11, Shenzhen, China

- Currently under construction
- Opening later this year
- Fastest Metro line in Shenzhen with speeds of 120 km/h
- Galvanized rebar is being produced by Xiamen Newsteel



G7 Beijing–Ürümqi Expressway

Connects the cities of Beijing, China, and Ürümqi, Xinjiang. When complete, it will be 2,540 km (1,580 mi) in length. Galvanized rebar is being produced by Xiamen New Steel



Continuous Galvanized Rebar

Low Cost

Tough

Corrosion Resistant

Formable

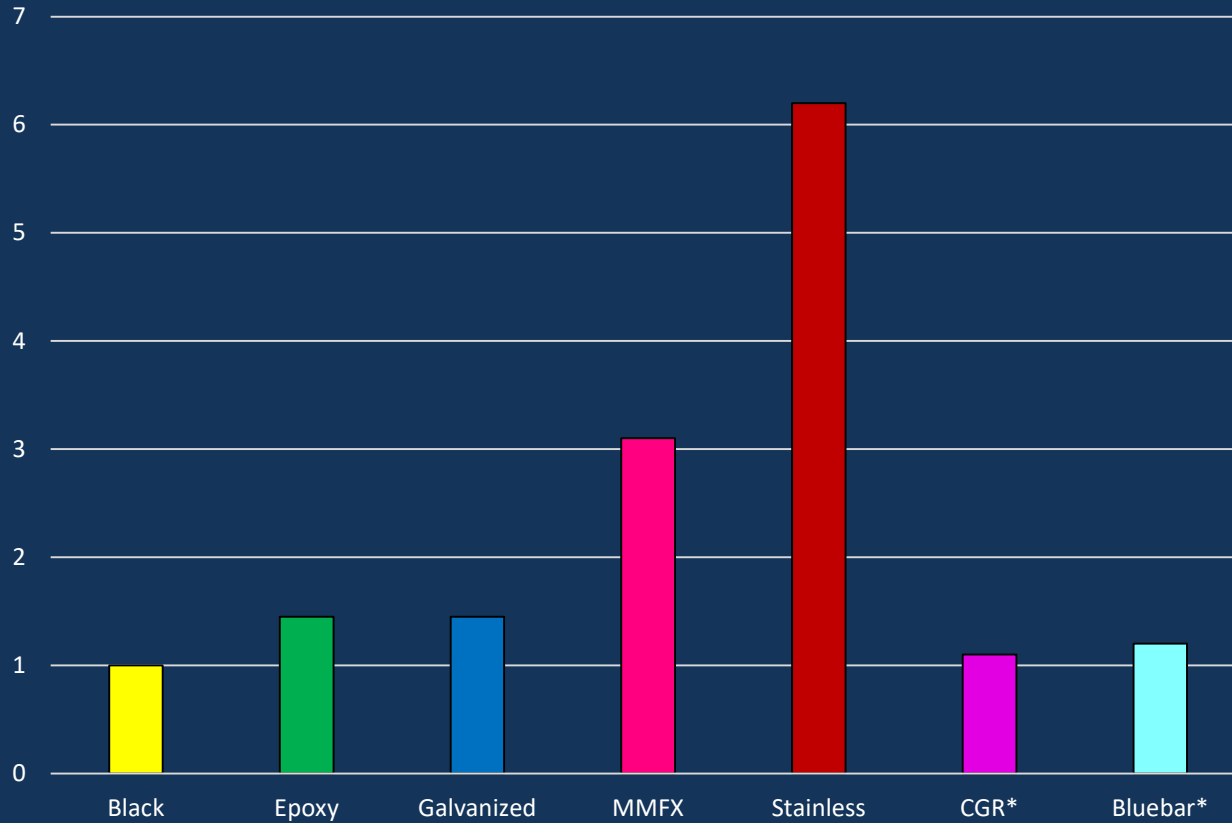
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Comparison versus Black Bar



FHWA, 2012
*estimated

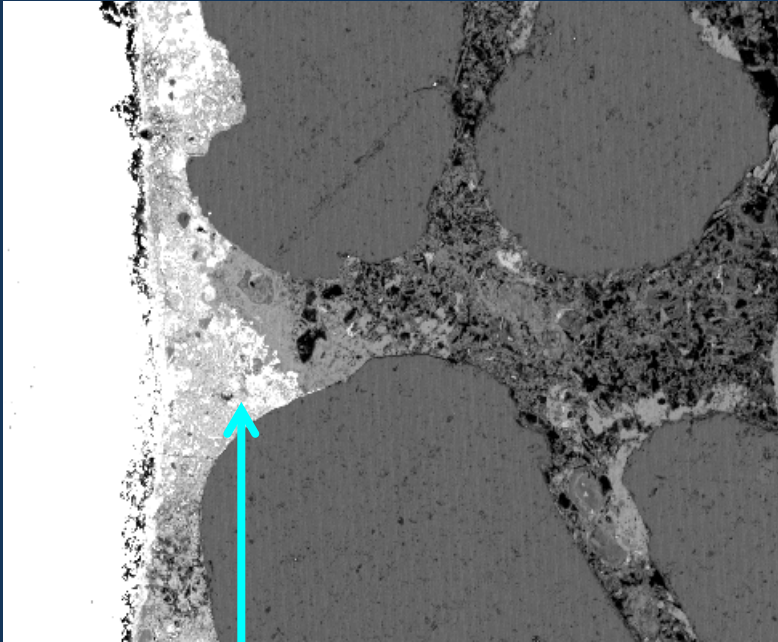


Zinc in Concrete

- Passivated by formation of a layer of adherent crystals
 - Calcium Hydroxyzincate (CHZ)
- Reaction begins upon contact with wet cement solution
 - Ceases once concrete hardens
- Surface film stabilizes the zinc
 - Second level of barrier protection

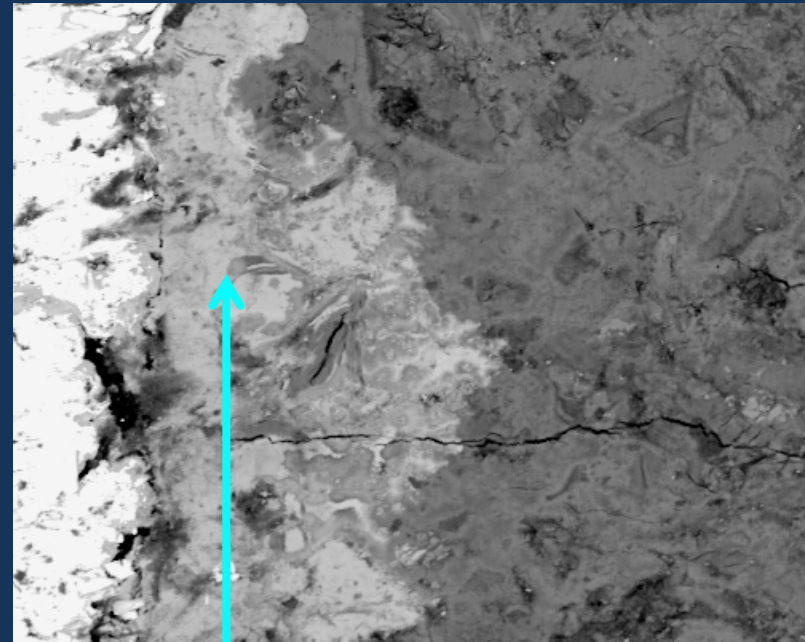


Migration of Zinc



100x

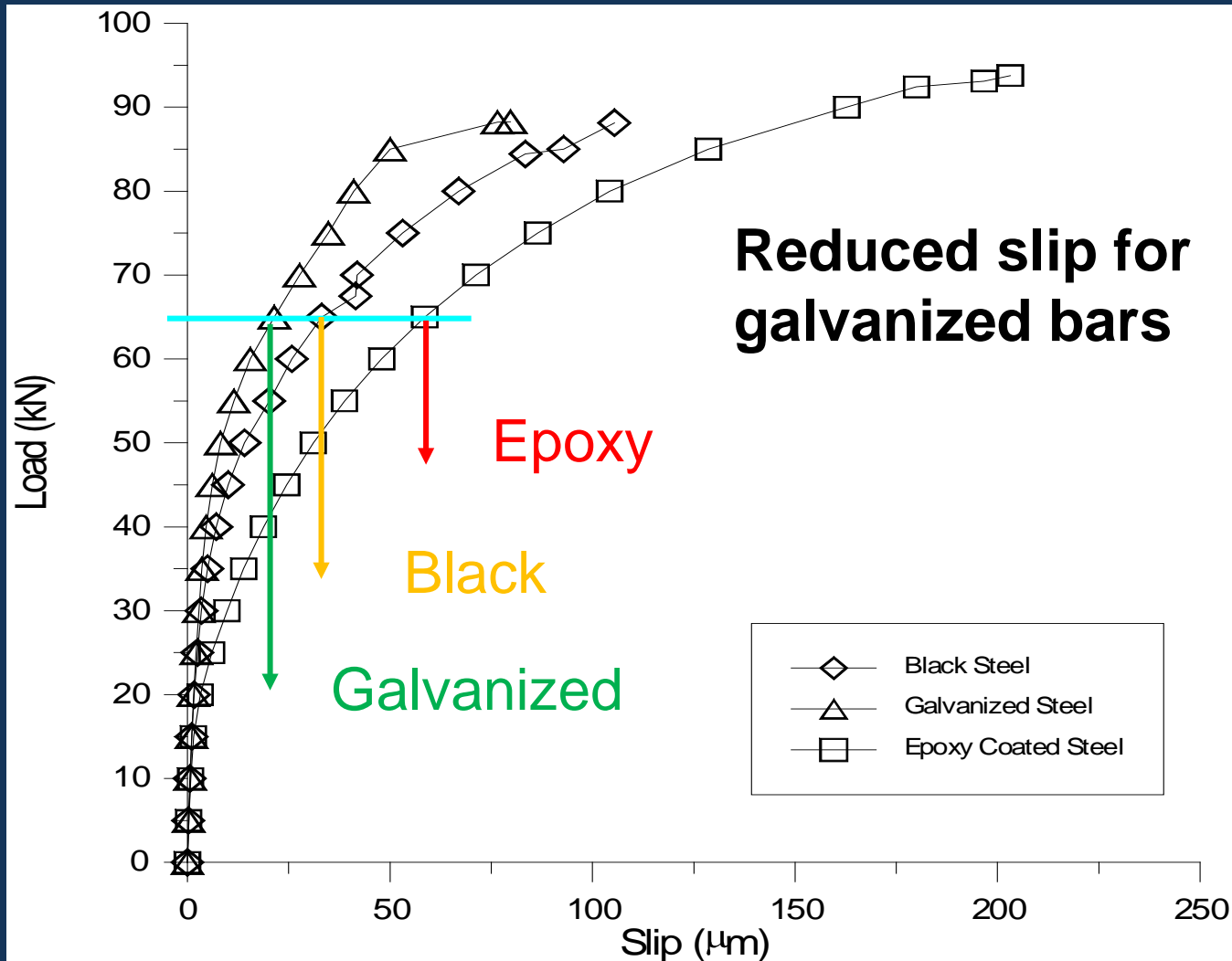
Migration of zinc-rich corrosion products away from the bar/matrix interface and well into the cement matrix.



1000x

Partial dissolution of the galvanized coating and zinc corrosion product migrating into the cement matrix.

Load-Slip Characteristics



Improved Corrosion Resistance

- Pure Zinc corrodes at a slower rate than Iron-Zinc Intermettalic
- Less zinc consumed to form CHZ passivation layer
- Less zinc required to provide corrosion resistance

Coating Type	Average Depth of Loss to Passivation (um)
Annealed (Intermettalic)	1.18
Pure Zinc	0.45

