Bridge—Concrete: Substructure TOC

CONTENTS

On the Cover

 Jean L. Broge

Hail to the Bridge

 Jean L. Broge

**1996**

**Electrochemical Chloride Extraction from Concrete Bridge Elements: Some Case Studies (Technical Paper C1996-00299)**

A look at the principle behind electrochemical chloride extraction (ECE) with descriptions and summary results of projects completed in North America. ECE reduces the chloride content within the concrete, eliminates harmful corrosion potentials, and reduces corrosion currents.

D.W. Whitmore, “Electrochemical Chloride Extraction from Concrete Bridge Elements: Some Case Studies,” CORROSION96, Technical Paper C1996-00299 (Houston, TX: NACE International, 1996).

**Bond Strength of Electrochemically Aged Arc-Sprayed Zinc Coatings on Concrete (Technical Paper C1996-00308)**

Reinforced concrete structures like bridges are particularly susceptible to salt-induced corrosion problems in coastal areas and in areas where deicing salts are used. Problems develop when salt permeates the concrete and accumulates at the rebar-concrete interface. Several approaches have been used to minimize rebar corrosion, including both epoxy coating and galvanizing the rebar, special concrete mix designs and sealing the concrete surface.

B.S Covino, Jr, S. J. Bullard, S.D. Cramer, G.R. Holcomb, G.E. McGill, and C.B. Cryer, “Bond Strength of Electrochemically Aged Arc-Sprayed Zinc Coatings on Concrete,” CORROSION96, Technical Paper C1996-00308 (Houston, TX: NACE International, 1996).

**Effect of Concrete Mix Components on Corrosion of Steel in Concrete (Technical Paper C1996-00334)**

The FHWA initiated a research project directed at the quantitative identification of the corrosive conditions fostering concrete bridge deterioration, and at the identification of concrete materials that consistently provide superior performance when used for bridge deck overlays and for the repair of other concrete bridge members. Another goal of the project was to identify cost-effective concretes for the construction of new bridge members.

N.G. Thompson and K.M. Lawson, “Effect of Concrete Mix Components on Corrosion of Steel in Concrete,” CORROSION96, Technical Paper C1996-00334 (Houston, TX: NACE International, 1996).

**1997**

**Interfacial Chemistry of Zinc Anodes for Reinforced Concrete Structures (Technical Paper C1997-00233)**

The chemistry of the zinc-concrete interface in laboratory electrochemical aging studies is compared with that of several bridges with thermal-sprayed zinc anodes and which have been in service for 5 to 10 years using both galvanic and impressed current cathodic protection systems.

B.S Covino, Jr, S. J. Bullard, S.D. Cramer, G.R. Holcomb, G.E. McGill, C.B. Cryer, A. Stoneman, and R.R. Carter, “Interfacial Chemistry of Zinc Anodes for Reinforced Concrete Structures,” CORROSION97, Technical Paper C1997-00233 (Houston, TX: NACE International, 1997).

**1998**

**Galvanic Metalized Zinc Cathodic Protection System for a Carbonated Reinforced Concrete Structure (Technical Paper (Technical Paper C1998-00645)**

A corrosion assessment survey was conducted with the objective of facilitating the selection of repair methods for the corrosion control of two reinforced concrete bridges. Results from preliminary field-testing indicated that these 75+ year old historically significant structures both exhibited widespread corrosion distress throughout most of the substructure components due to carbonation of the concrete matrix.

I. Sitton and J.E. Costa, “Galvanic Metalized Zinc Cathodic Protection System for a Carbonated Reinforced Concrete Structure,” CORROSION98, Technical Paper C1998-00645 (Houston, TX: NACE International, 1998).

**1999**

**A Galvanic Zinc-Hydrogel System for Cathodic Protection of Reinforced Concrete Structures (Technical**

**Paper C1999-00551)**

There are many methods currently being used to protect concrete structures against corrosion, including waterproof coatings, corrosion inhibitors, and impressed current cathodic protection systems. Each of these methods has its own advantages and disadvantages. The authors suggest that galvanic zinc-hydrogel anode system eliminates most of these disadvantages.

J.E. Wehling, “A Galvanic Zinc-Hydrogel System for Cathodic Protection of Reinforced Concrete Structures,” CORROSION99, Technical Paper C1999-00551 (Houston, TX: NACE International, 1999).

**Non-Destructive Evaluation of Jacketed Pre-Stressed Concrete Piles for Corrosion Damage (Technical Paper C1999-00566)**

Jacketing has been employed historically in Florida and elsewhere as a repair and rehabilitation method for corrosion-damaged coastal bridge pilings. Experience has indicated, however, that jacketing for corrosion control is not effective and may accelerate subsequent attacks.

M. Rapa and W.H. Hartt, “Non-Destructive Evaluation of Jacketed Pre-Stressed Concrete Piles for Corrosion Damage,” CORROSION99, Technical Paper C1999-00566 (Houston, TX: NACE International, 1999).

**2000**

**Results of Long-Term Monitoring of Corrosion Inhibitors Applied to Corroding Reinforced Concrete Structures (Technical Paper C2000-00791)**

Starting with a thorough definition/classification of what corrosion inhibitors are, the author then presents long-term data that questions when and where they should be used.

J.P. Broomfield, “Results of Long-Term Monitoring of Corrosion Inhibitors Applied to Corroding Reinforced Concrete Structures,” CORROSION 2000, Technical Paper C2000-00791 (Houston, TX: NACE International, 2000).

**Influence of Permeability Reducing and Corrosion Inhibiting Admixtures in Concrete Upon Initiation of Salt-Induced Embedded Steel Corrosion (Technical Paper C2000-00802)**

While the utility of permeability reducing and corrosion inhibiting admixtures in concrete for forestalling the onset of corrosion initiation is generally recognized, there remains a general non-availability of long-term data upon which quantitative performance projections can be made. The authors take on that challenge. structures and components exposed to environments that contain significant

S. Charvin, W.H. Hartt, S. Lee, and R.G. Powers, “Influence of Permeability Reducing and Corrosion Inhibiting Admixtures in Concrete Upon Initiation of Sale-Induced Embedded Steel Corrosion,” CORROSION 2000, Technical Paper C2000-00802 (Houston, TX: NACE International, 2000).

**Field Experience and Long-Term Monitoring of Some Reinforced Concrete Bridge Structures Subjected to Electrochemical Chloride Extraction (Technical Paper C2000-00821)**

Since the early 1990’s hundreds of reinforced concrete structures worldwide have been treated with ECE. In the U.S. most of the structures were installed through funding from the FHWA. The authors present the results of ECE effectiveness of four structures that were monitored from 1995-1998.

D.R. Jackson and M. Islam, “Field Experience and Long-Term Monitoring of Some Reinforced Concrete Bridge Structures Subjected to Electrochemical Chloride Extraction (ECE),” CORROSION 2000, Technical Paper C2000-00821 (Houston, TX: NACE International, 2000).

**2002**

**Inspecting a Half-Century Concrete Pier Made with Stainless Steel Reinforcement in Mexico (Technical Paper C2002-02207)**

A 60-year old reinforced concrete pier, constructed with stainless steel rebar and exposed to a tropical marine environment, has shown good performance during its service life. Visual inspection has shown no deterioration symptoms on sub- and superstructures while recent marine structures (adjacent or close to this pier), constructed in the last three decades have significantly deteriorated. The authors investigate why.

P. Castro-Borges, O.T. Troconis-Rincón, E.I. Moreno, A.A. Torres-Acosta, M. Martínez-Madrid, and A. Knudsen, “Inspecting a Half-Century Concrete Pier Made with Stainless Steel Reinforcement in Mexico,” CORROSION 2002, Technical Paper C2002-02207 (Houston, TX: NACE International, 2002).

**2003**

**A Study on Corrosion Resistance of Prestressed Marine Concrete Piles (Technical Paper C2003-03239)**

This study addresses the resistance to chloride ion penetration in large prestressed concrete piles exposed to severe marine splash/tidal zones. The influences of environmental characteristics, manufacturing processes, and local experiences were considered.

W. Ahn, D. Joque, and A. Rusten, “A Study on Corrosion Resistance of Prestressed Marine Concrete Piles,” CORROSION 2003, Technical Paper C2003-03239 (Houston, TX: NACE International, 2003).

**Long-Term Effectiveness of Corrosion Inhibitors Used in Repair of Reinforced Concrete Bridge Components (Technical Paper C2003-03286)**

The primary goal of this study was to determine the effectiveness of migrating amine based organic and calcium-nitrite-based inorganic inhibitors in mitigating corrosion though a five-year study. The inhibitors had been used in the repair of substructure and superstructure elements of four bridge structures during the SHRP field validation study.

A.A. Sohanghpurwala, “Long-Term Effectiveness of Corrosion Inhibitors Used in Repair of Reinforced Concrete Bridge Components,” CORROSION 2023, Technical Paper C2003-03286 (Houston, TX: NACE International, 2003).

**2006**

**Corrosion Performance of Concrete Cylinder Piles (Technical Paper C2006-06335)**

Concrete cylinder piles produced by a centrifugally cast, vibrated, roller-compacted process have shown promising corrosion resistance in marine environments. In the paper, three bridges in the Florida panhandle with ~40 years in aggressive marine service, and one newly constructed marine bridge utilizing concrete cylinder piles, are examined.

K. Lau, A.A. Sagüés, and R.G. Powers, “Corrosion Performance of Concrete Cylinder Piles,” CORROSION 2016, Technical Paper C2006-06335 (Houston, TX: NACE International, 2006).

2007

**A Proposed Protocol for Classifying Corrosion-Damaged Prestressed Concrete Pilings on Coastal Bridges (Technical Paper C2007-07288)**

Corrosion induced cracking, delamination, and spalling of prestressed coastal bridge pilings presents a

formidable challenge to maintenance and maintenance planning. Particularly needed is a protocol whereby engineers can prioritize corrosion damaged pilings according to deterioration severity and reduced load bearing capacity.

W.H Hartt, W.T. Scannell, D.B. Thompson, I. Lasa, and D. Buwalda, “A Proposed Protocol for Classifying Corrosion-Damaged Prestressed Concrete Pilings on Coastal Bridges,” CORROSION 2007, Technical Paper C2007-07288 (Houston, TX: NACE International, 2007).

**2008**

**Specimen Type and Test Protocol for Corrosion Performance Characterization of Reinforced Concrete Marine Pilings (Technical Paper C2008-08320)**

Sea water induced reinforcing steel corrosion is often service life limiting for concrete bridge pilings in

marine environments. In the present research, a novel piling type specimen assembly and test protocol were developed to simulate performance of actual substructure elements undergoing marine exposure.

R.E. Tanner and W.H. Hartt, “Specimen Type and Test Protocol for Corrosion Performance Characterization of Reinforced Concrete Marine Pilings,” CORROSION 2008, Technical Paper C2008-08320 (Houston, TX: NACE International, 2008).

**2009**

**Preliminary Results of Surface Resistivity Readings (Wenner Method) on Field Marine Substructures as a Mean to Assess Concrete Permeability (Technical Paper C2009-09218)**

Surface resistivity profiles as a function of elevation were measured on recent and mature marine reinforced concrete substructures. In a later phase of the project the surface resistivity values measured will be correlated with chloride diffusion coefficients measured from the same structures.

F. Presuel-Moreno, A. Suarez, M. Paredes, and I. Lasa, “Preliminary Results of Surface Resistivity Readings (Wenner Method) on Field Marine Substructures as a Mean to Assess Concrete Permeability,” CORRIOSION 2009, Technical Paper C2009-09218 (Houston, TX: NACE International, 2009).

**2010**

**A Protocol for Projecting Time-to-Corrosion of Reinforcing Steel in Concrete Exposed to Chlorides (Technical Paper C2010-10123)**

The author proposes that reinforced concrete durability should be characterized not simply in terms of the time at which corrosion initiates for a small percentage of the reinforcement, as is normally done, but also by the rate at which active corrosion subsequently begins for the remaining, uncorroded reinforcement.

W.H. Hartt, “A Protocol for Projecting Time-to-Corrosion of Reinforcing Steel in Concrete Exposed to Chlorides,” CORROSION 2010, Technical Paper C2010-10123 (Houston, TX: NACE International, 2010).

**A Review of Biodeterioration of Concrete Structures (Technical Paper C2010-10216)**

This paper provides a review of test procedures for identification of microbial attack to concrete; identification of the factors causing initiation of microbial attack; operative mechanism of microbial attack; and identification of practical preventive measures that can be taken to avoid or minimize damage to concrete structures.

S. Nasrazadani and E. Sudoi, “A Review of Biodeterioration of Concrete Structures,” CORROSION 2010, Technical Paper C2010-10216 (Houston, TX: NACE International, 2010).

**2011**

**Corrosion Initiation Projection for Reinforced Concrete Exposed to Chlorides – Part 1: Black Bars (Technical Paper C2011-11006)**

Reinforcing steel in concrete is normally passive and corrosion rate negligible cause of relatively high cement pore water alkalinity. Such passivity can be compromised, however, by either carbonation or by chlorides achieving a critical concentration at the steel depth, leading to concrete cracking and spalling, and reduced service life.

W.H. Hartt, “Corrosion Initiation Projection for Reinforced Concrete Exposed to Chlorides –Part 1: Black Bars,” CORROSION 2011, Technical Paper C2011-11006 (Houston, TX: NACE International, 2011).

**2013**

**Early Corrosion Testing on Concrete and the Importance of the Interpretation to Provide Long-Term Preventive Measures (Technical Paper C2013-02752)**

Corrosion engineers have often stressed the need for stricter procedures on when, what, and who should be assessing corrosion behavior that leads to the degradation of billions of dollars in infrastructure. Preventative maintenance and testing guidelines must be established before a structure is borne.

P.A. Noyce and G.L. Crevello, “Early Corrosion Testing on Concrete and the Importance of the Interpretation to Provide Long-Term Preventive Measures,” CORROSION 2013, Technical Paper C2013-02752 (Houston, TX: NACE International, 2013).

**2016**

**Modeling and Control of Localized Corrosion of Steel in Submerged Reinforced Concrete Structures (Technical Paper C2016-07766)**

The authors present a quantitative model to forecast corrosion damage in submerged concrete in marine environments. The model incorporates Potential Dependent Threshold (PDT) features and determines the damage function for affected structures.

M.T. Walsh and A.A. Sagüés, “Modeling and Control of Localized Corrosion of Steel in Submerged Reinforced Concrete Structures,” CORROSION 2016, Technical Paper C2016-07766 (Houston, TX: NACE International, 2016).

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