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Advancing concrete knowledge


123 Forum: What's the Current State of Epoxy-Coated Reinforcing Steel?

ACI Spring 2011 Convention
April 3 - 7, Tampa, FL

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ACI Conventions

ACI conventions provide a forum for networking, learning the latest in concrete technology and practices, renewing old friendships, and making new ones. At each of ACI's two annual conventions, technical and educational committees meet to develop the standards, reports, and other documents necessary to keep abreast of the ever-changing world of concrete technology.

With over 1,300 delegates attending each convention, there is ample opportunity to meet and talk individually with some of the most prominent persons in the field of concrete technology. For more information about ACI conventions, visit www.aciconvention.org.




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This ACI Web Session includes 2 speakers presenting at the ACI spring convention held in Tampa, FL April 3 – 7, 2011. Additional presentations will be made available in future ACI Web Sessions.

Please enjoy the presentations.



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**123 Forum: What's the
Current State of Epoxy-Coated
Reinforcing Steel?**

ACI Spring 2011 Convention
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David Darwin, former ACI President, is the Deane E. Ackers Distinguished Professor of Civil, Environmental, and Architectural Engineering and Director of the Structural Engineering and Materials Laboratory at the University of Kansas. He is a Fellow of the Institute and a member of ACI Committees 130, Sustainability of Concrete; 222, Corrosion of Metals in Concrete; 224, Cracking; 318-B, Reinforcement and Development (Structural Concrete Building Code); 408, Bond and Development of Reinforcement; 446, Fracture Mechanics; and Joint ACI-ASCE Committee 445, Shear and Torsion. Dr. Darwin has made important contributions in the fields of finite element analysis of reinforced concrete, steel-concrete composite structures, bond between reinforcing steel and concrete, concrete materials, corrosion, and bridge construction. In addition to bond studies, the major thrust of his current work involves methods of improving the durability of bridges, with special emphasis on reducing corrosion of reinforcing steel and cracking in reinforced concrete bridge decks.




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**Evaluation of Multiple Corrosion
Protection Strategies used in
Conjunction with Epoxy-Coated
Reinforcement**

By
David Darwin
University of Kansas

ACI Convention
Tampa, Florida
April 3, 2011



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Research supported by:

- FHWA
- KDOT
- Industry

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Outline

- Corrosion Protection Systems
- Tests
- Results

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Multiple corrosion protection systems

■ Corrosion inhibitors

- ECR w/ $\text{Ca}(\text{NO}_2)_2$ (DCI)
- ECR w/Rheocrete 222+
- ECR w/Hycrete
- 3M – primer containing $\text{Ca}(\text{NO}_2)_2$

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Multiple corrosion protection systems

■ Multiple coatings

- Zinc + ECR

■ Increased adhesion

- Chromate pretreatment
- DuPont coating
- Valspar coating

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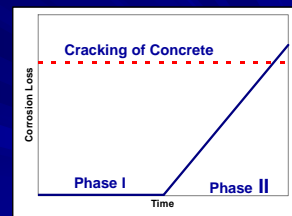
■ Corrosion inhibitors with conventional steel

- $\text{Ca}(\text{NO}_2)_2$ (DCI)
- Rheocrete 222+
- Hycrete

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Chloride Induced Corrosion

- Two phase process:
- Phase I – initiation
 - Time to reach the critical chloride corrosion threshold
- Phase II – corrosion
 - Corrosion products build up around reinforcement



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Bench-Scale Tests



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Field Tests



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Comparisons

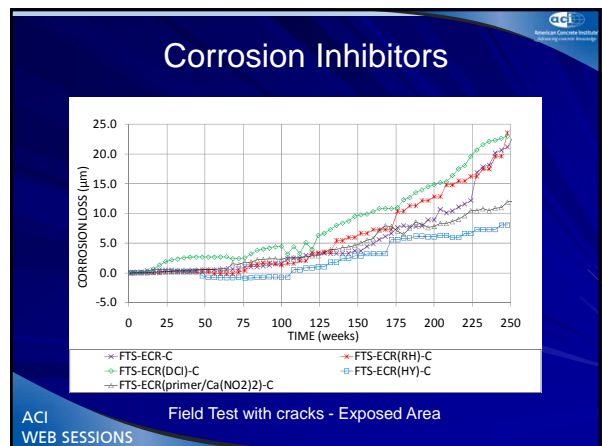
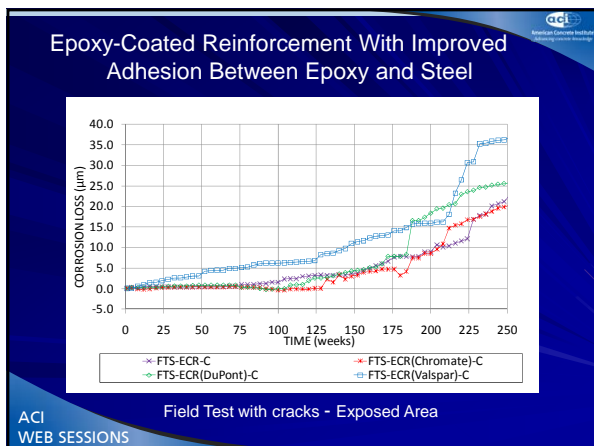
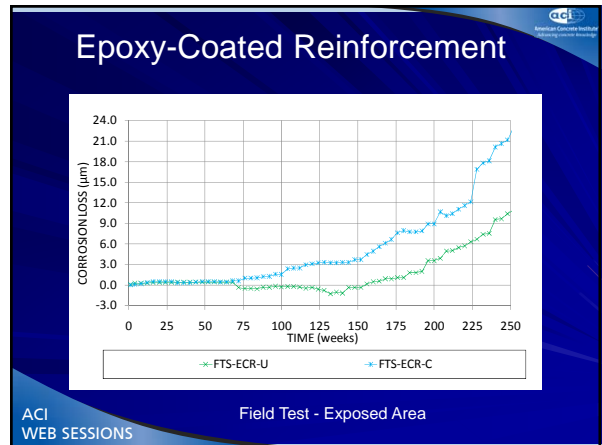
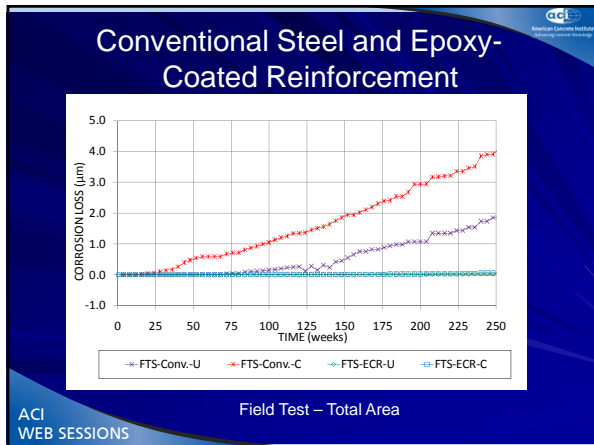
- Chloride corrosion threshold
- Field tests
- Life expectancy and cost-effectiveness

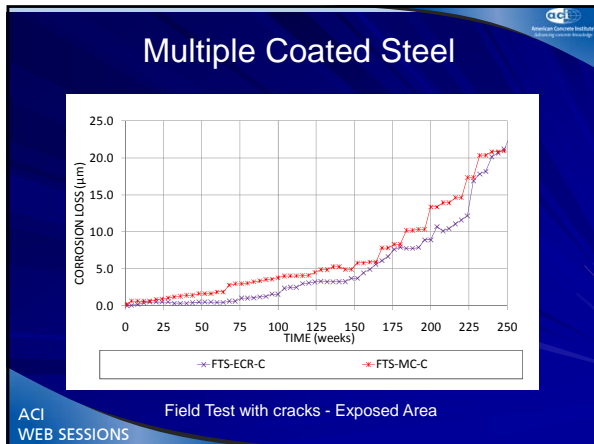
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Chloride Threshold, lb/yd³

- Uncoated bars
 - Conventional 1.6
 - Conventional (DCI) 3.0
 - Conventional (RH) 2.3
 - Conventional (HY) 0.8
- Coated Bars
 - ECR 8.4
 - ECR (DCI) 8.7
 - ECR (RH) 6.9
 - ECR (HY) 1.8
 - ECR (primer/Ca(NO₂)₂) 12.0
 - MC 3.4

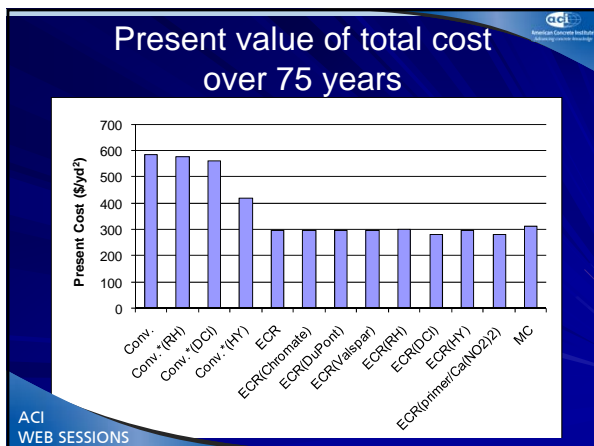
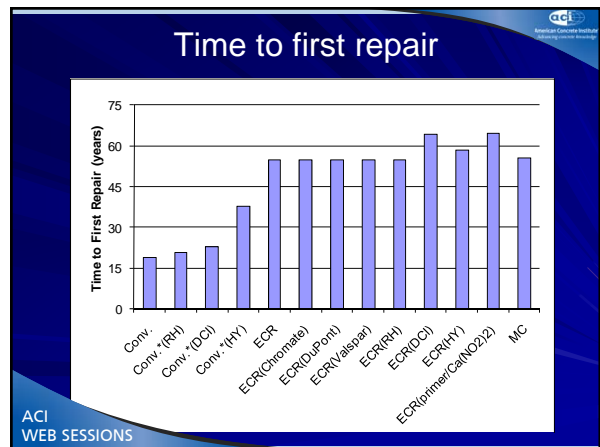
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Life expectancy and cost-effectiveness

- ### Comparisons based on:
- 150 ft span, 36 ft width, 8.5 in. deck
 - 75-year economic life
 - KDOT and SDDOT costs



- ### Conclusions
- Epoxy coating significantly improves
 - corrosion resistance
 - life expectancy
 - cost-effectiveness
 - Additional protection provides limited improvement



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Dr. William Hart is Emeritus Professor of Ocean Engineering and former Director of the Center for Marine Materials at Florida Atlantic University. Over the past three decades, he has directed and co-directed a series of research programs sponsored by the Federal Highway Administration, Strategic Highway Research Program, National Cooperative Highway Research Program, Florida Department of Transportation, and the private sector that have addressed deterioration and deterioration control of reinforced concrete structures. Dr. Hart is an active member of NACE International, The Corrosion Society, having served on the Board of Directors, as Chair of the Corrosion of Metals in Cementitious Materials Committee (1985-1987). Dr. Hart has been designated a Fellow by NACE International and has received that organization's Distinguished Service Award. Dr. Hart presently chairs the National Academies Transportation Research Board Committee AHD45 on Corrosion. He has authored over 75 papers in referred journals and made over 100 presentations at national and international conferences, many of which pertained to corrosion and corrosion control of reinforcing steel in concrete.

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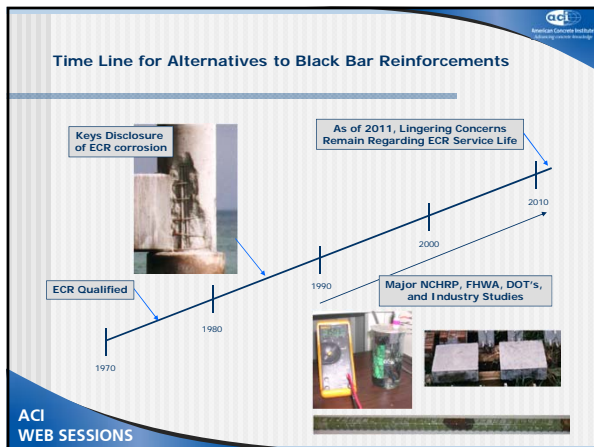
What is the Current State of Epoxy-Coated Reinforcing Steel?

A Forum Sponsored by ACI Committee 123, Research and Current Developments
April 3, 2011

AN INDEPENDENT PERSPECTIVE OF ECR UTILITY AS CORROSION RESISTANT REINFORCEMENT

William H. Hart
Professor Emeritus
Florida Atlantic University – Sea Tech Campus
101 North Beach Road
Dania Beach, Florida USA

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Knowns and Unknowns

Known:

- With the exception of the Keys bridges, ECR has clearly outperformed BB in situations where side-by-side comparisons were possible.
- Results from numerous test yard studies.
- Results from the West Virginia bridge deck study.
- Occurrence of soffit concrete spalling on bridge decks with ECR top mat and BB bottom.
- Although failures have been reported, in general ECR has performed well to-date in northern bridge decks.

Unknown:

- The service life that will result for ECR in concrete exposed to chlorides.

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The Importance of Coating Defects

Macrocell current for specimens with large numbers of coating defects was ~10% of that for BB only specimens. Most investigators, however, have reported such current to be low or nil.

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Reasons for Lingering Concerns

1. The Florida experience.
2. The Ken Clear experience.
 - a) One year duration 'Southern Exposure' testing of ECR-BB slabs.
 - b) Ten months tap water ponding followed by 9.5 months outdoor exposure in northern Va.
 - c) Virtually complete coating failure and active corrosion.

This begs the question: Are Southern Exposure testing results indicative of long-term ECR performance?
3. The VDOT experience.
4. The Canadian (OMT) experience.

Corrosion of ECR disclosed in barrier walls and bridge decks.

OMT now uses stainless steel in decks with more than 100k ADT because of their ECR corrosion experience and the major disruption that results from shutdowns.

Canadian Standards Association cautions regarding use of ECR.

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Summarizing Schematic

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Summarizing Comments

1. With exceptions, ECR has performed well to-date in northern bridge decks.
2. Multiple investigators have reported that ECR adhesion is reduced with time irrespective of chlorides.
3. Multiple investigators have also projected that ECR has performed well to-date in high quality concrete with good cover but not necessarily well when either of these two considerations is lacking.
4. While first-principles based analysis methods are now available to project service life of uncoated bars, such analyses are not possible in the case for ECR.
5. Interpolation is a proven engineering tool; however, extrapolation is not. Consequently, the service life that can be expected with ECR is unknown.

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Summarizing Comments

Where in our society do we apply an epoxy coating to carbon steel, expose it to moisture and chlorides, and expect a 75 year life?

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Questions & Answers

Discussion

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