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OVERVIEW OF EPOXY-COATED AND ALTERNATIVE CORROSION RESISTANT REINFORCEMENTS

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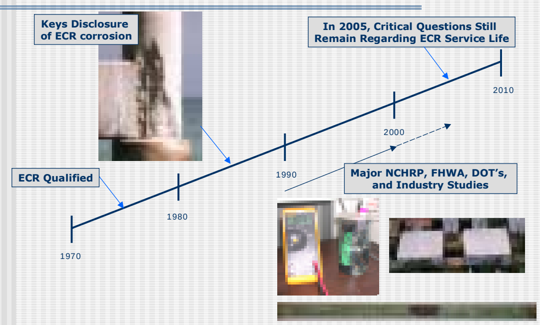
Historical Perspective of Corrosion Induced Reinforced Concrete Deterioration

Largely because of adoption of the "clear roads" policy in the 1960's and the resultant use of deicing salts on northern bridge decks and roadways, concrete cracking and spalling as a consequence of reinforcing steel corrosion was identified in the 1970's as the major cause of premature bridge deterioration.

Based on extensive testing, epoxy-coated reinforcement was approved/mandated for northern bridge decks and marine substructures in the mid-1970's.

The finding in the mid-1980's that ECR bridge substructures in the Florida Keys exhibited corrosion induced cracking and spalling as soon as six years subsequent to construction (the same as projected for black bar) resulted is several major research efforts that, first, addressed the cause of this premature deterioration and, second, reconsidered the suitability of ECR for long-term service in chloride contaminated concrete.

Time Line for Alternatives to Black Bar Reinforcements

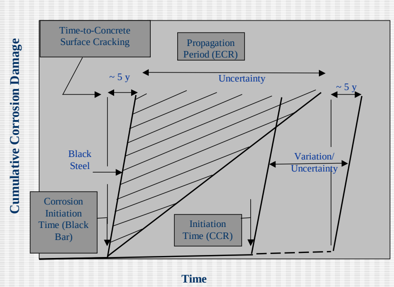


Performance of ECR in Test Year Exposures

The three most important factors in assuring long-term ECR performance:

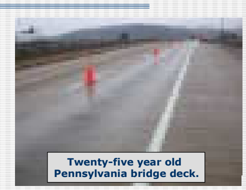
Control of coating defects.
Control of coating defects.
Control of coating defects.

Damage Accumulation Projection for Different Type Reinforcements



ECR Service Experience and The Critical Question

The Florida Keys bridge substructures aside, ECR service experience in northern bridge decks has been generally good; and where side-by-side comparisons have been possible, ECR has clearly out-performed black bar.



The critical question: Can ECR achieve the requisite 75-100 year design life that is now required for major bridge structures?

In the absence of a confident affirmative answer, attention has focused during the past several years upon alternative, more corrosion resistant reinforcements.

Corrosion Resistant Reinforcement FHWA/FDOT Sponsored Research Project

Candidate Alloys

- Type 304 SS
- Type 316 SS
- Type 2205 SS
- Type 2201 SS+
- Type 3Cr12 SS
- Clad Type 316 SS
- 1. Stelax*
- 2. SMI*
- MMFX-II*
- Black Bar

Short-Term Experiments:

- AST-1 Wet-Dry Exposure
- AST-2 A Potentiostatic Tests
- AST-2 B Potentiodynamic Polarization Scans
- Atmospheric Exposures

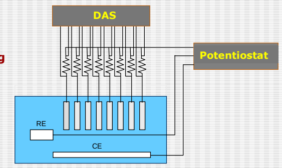
Long-Term Experiments

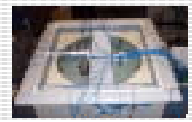
- Reinforced Concrete Slab Exposures

Note: Default testing condition is with bars as-received.
* Testing in the surface abraded and surface damaged conditions.
+ Testing in the pickled condition.

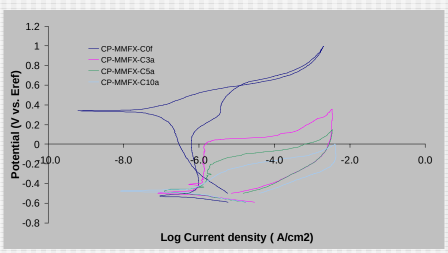
AST-2 Experimentation

Multiple specimens in SPS at RT maintained at a constant potential of +100 mV (SCE). Monitor applied current while incrementally increasing Cl^-. Retrieve bars once critical [Cl^-] is reached.

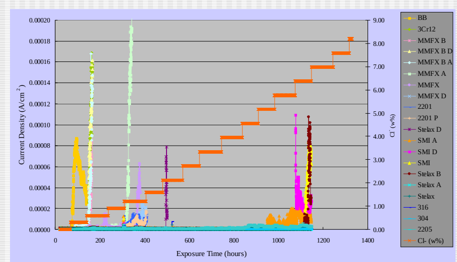




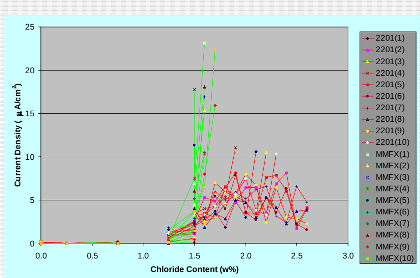
Potentiodynamic Polarization Scan Illustration of the Potential–Chloride–Pitting Initiation Interrelationship



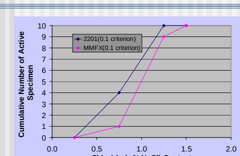
Initial AST Experimental Results

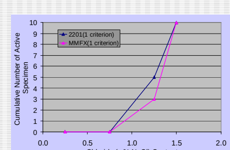


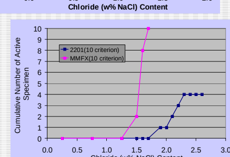
MMFX/2201 Comparison



Criterion for Defining Corrosion Activation



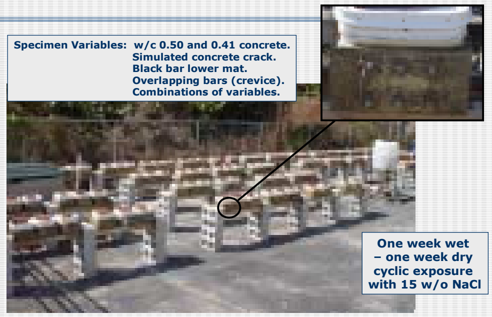




316≈304≈2205≈SSC1(Stelax)> SSC2(SMI)>2201>MMFX>3Cr12>BB

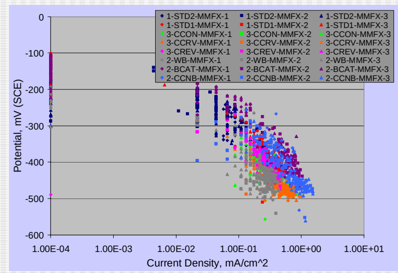
Test Yard Exposures

Specimen Variables: w/c 0.50 and 0.41 concrete.
Simulated concrete crack.
Black bar lower mat.
Overlapping bars (crevice).
Combinations of variables.

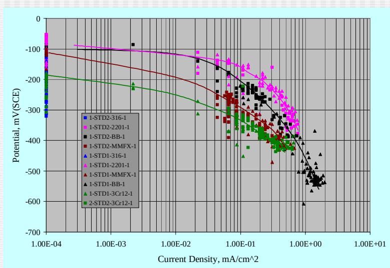


One week wet – one week dry cyclic exposure with 15 w/o NaCl

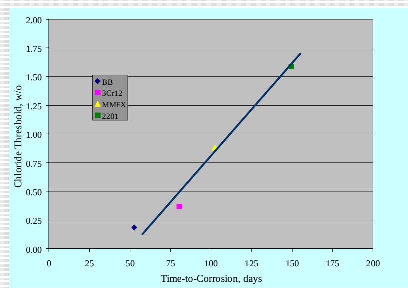
Potential – Macro-Cell Current Density Data – MMFX Steel



Potential – Macro-Cell Current Density Data Summary



Accelerated Test – Long-Term Exposure Correlation



Conclusions

1. **It is uncertain that ECR will provide the desired 75-100 year design life for northern bridge decks and marine substructures.**
2. **Stainless steels, including clad bars, are a technically acceptable alternative to ECR.**
3. **Because there are a variety of corrosion resistant reinforcement alternatives, materials selection can be tailored to the anticipated exposure severity.**
4. **Preliminary results indicate a correlation between the critical Cl^- concentration for corrosion initiation on corrosion resistant reinforcements, as measured in short-term potentiostatic tests, and time-to-corrosion of reinforcement in concrete slabs. If this turns out to be the case and the relationship between Cl^- threshold and time-to-corrosion can be quantified, then the designer should have a powerful tool for materials selection and service life modeling.**