

Bridge Preservation / Management

Better Assessment in the use of
Bridge Deck Preservation Treatments



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May 2013

Goals

Maximizing the Life-Cycle Potential of a Concrete Bridge Deck



- Better understand how material related distresses contribute to early age bridge deck failure
- Understand the triggers for the use of various bridge deck preservation treatments
- Assessing bridge deck condition for the use of bridge deck treatments
- Potential failure mechanisms of bridge deck overlay systems
- When is it time to cut your losses and consider rehabilitation or deck replacement

“Preservation”

Why Funding for Maintenance?

“Investment in maintenance pays dividends for years to come; on (maintaining) a bridge or culvert It is an approach that just makes sense.” *a dollar we spend today can save as much as ten dollars for a full replacement.*

*Vermont Governor Jim Douglas
Quoted in AGC/VT Build Board,
January 2008*



What type of external influence may have contributed to this type of concrete deck failure?

Contribution to Early Age Bridge Deck Failure

EARLY TRIGGER: Plastic shrinkage, thermal cracking, drying shrinkage etc...



Water, penetrating through these cracks, is the most important substance that is involved in virtually every form of concrete deterioration-freezing-thawing damage, reinforcement corrosion, alkali-aggregate reactions, dissolution, sulfate attack and carbonation (Cody, 1994).

Contribution to Early Age Bridge Deck Failure

A concrete bridge deck can retain a lot of water?



Early Use of Low Viscosity Healer / Sealer on a Concrete Bridge Deck

1981 – The Rio Vista lift span would gain so much weight when it rained that Caltrans had to adjust the counterweights every rainy season. The cracks in the deck were sealed with a HMWM Monomer, the counterweights have not had to be adjusted since.

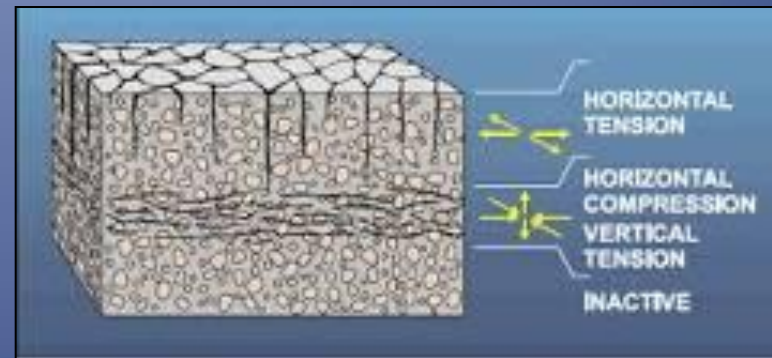
(CAL TRANS STUDY # F79TL 14 revised 02/25/92)

Materials-Related Distress (MRD)

Crystalline Growth Pressure Development

CHEMICAL MECHANISMS

- Alkali–Silica Reactivity (ASR)
 - Alkali–Carbonate Reactivity (ACR)
 - External Sulfate Attack (ESA)
 - Internal Sulfate Attack (ISA)
 - Delayed Ettringite Formation (DEF)
- (It is believed that both SEF (Secondary Ettringite Formation) and DEF (Delayed Ettringite Formation) are forms of internal sulfate attack)

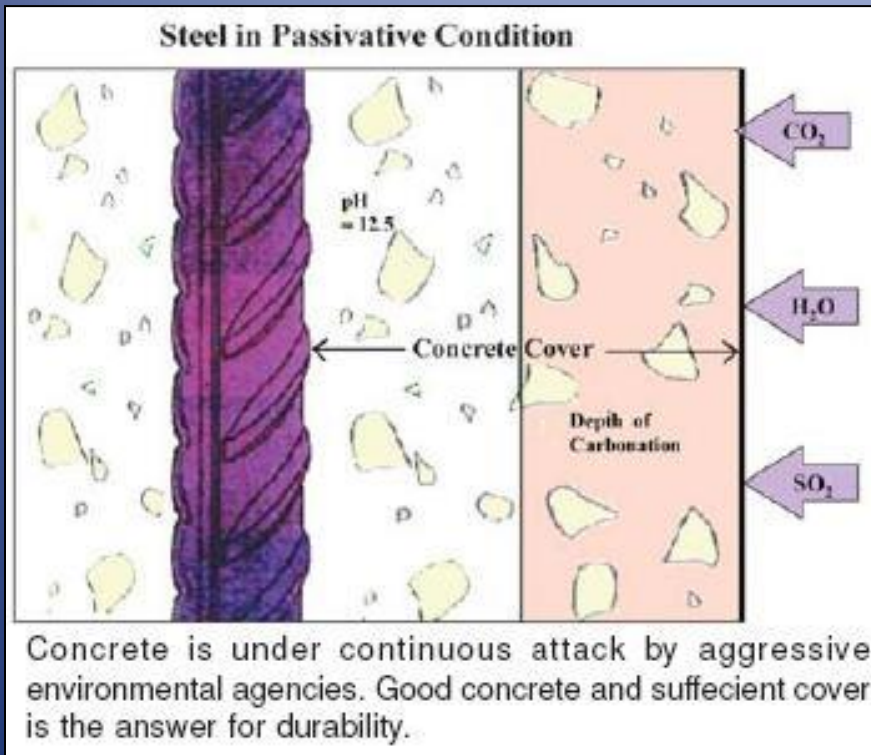


Cracking - caused by Alkali–Silica Reactivity (ASR)
This reaction causes a gel which expands when water is available

Carbonation

Carbonation of concrete is a process by which carbon dioxide from the air penetrates into concrete and reacts with calcium hydroxide to form calcium carbonates.

The lowering of PH levels in concrete around the reinforcing steel compromises the passive protective layer around the steel thus increasing corrosion potential



Common Treatments for Bridge Deck Preservation

- Crack Sealing by Flood Coat – Healer/Sealer
 - HMWM, LV Epoxy, MMA, Urethane, etc.
- Thin-Bonded, Multi-Layer, Polymer Overlay
 - Modified Polyester, LM Epoxy, MMA, Urethane, etc.
- Polyester Polymer Concrete – PPC
- Low Slump Concrete, Latex Modified Concrete, Microsilica Concrete



Bridge Deck Protection-Healer Sealer

Trigger for use : Cracks in deck concrete wider than 0.007 in.

- Seals cracks in concrete to prevent the intrusion of moisture, chlorides and other corrosion causing materials
- Reduction of crystalline growth pressure development
- Increases freeze-thaw durability
- Fills cracks to prevent edge spalling and deterioration



HMWM - Caltrans Concrete Core

American Concrete Institute ACI recommended tolerable crack width for structures exposed to deicing chemicals is 0.007 in. - (ACI) 204 as a trigger for planned maintenance activities.

Bridge Deck Protection-Healer Sealer

Trigger : Deck Condition

- Early age cracking : Low cost early age protection from the intrusion of moisture and other deleterious chemicals
- Extreme cracking : Low cost solution to add life to a deck that is beyond being a good candidate for a thin polymer overlay and rehabilitation of the deck is too costly at this time

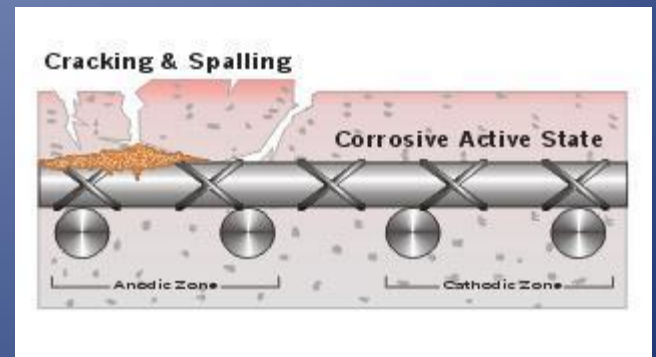
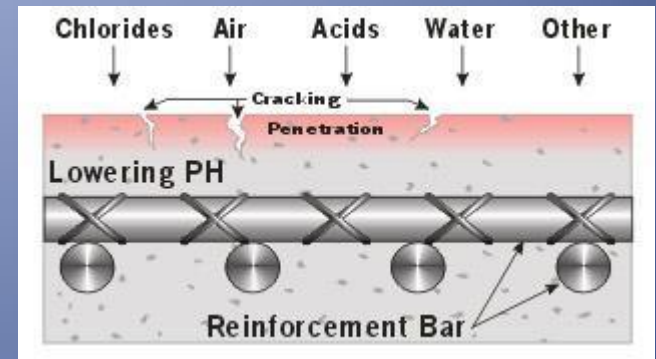


SHRP-S-344

(Strategic Highway Research Program)

New bridge decks with a 1.75in avg. cover should show signs of chloride-induced corrosion (chloride ion content equals 1lb/yd³ [0.63 kg/m³]) as follows when the average chloride application rate is moderate:

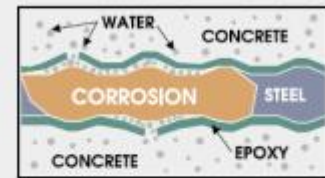
- 13 years when no protection treatment is used
- 25 years when a polymer sealer is maintained
- 77 years when a polymer overlay is maintained



What about ECR ?



The Bottom Line



Evaluations of ECR in approximately 250 concrete samples from 18 bridge decks across Virginia indicate that the epoxy coating debonds from the reinforcement in as little as 4 years and long before chlorides arrive at the level of the reinforcement. Assuming a debonded coating will provide for little additional service life, ECR should not be used to extend the service life of bridges in Virginia.

Thin-Bonded, Multi-Layer, Polymer Overlay



Trigger for use: Deck is still in good-excellent condition with <5% spalled, de-bonded or patched, minimal chloride contamination & > 250 psi strength of substrate (deck concrete)

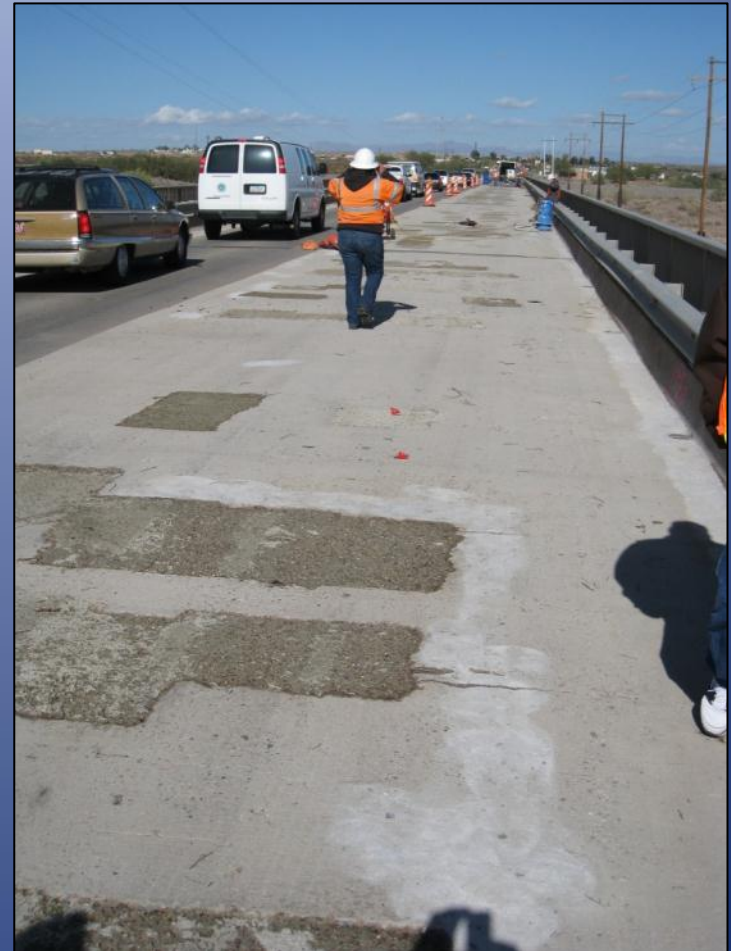
Condition Assessment

Criteria for Thin Bonded Polymer Overlay

“Once the deck deteriorates and requires patching on more than 5% of the deck, the overlay will most likely perform well for only a few years.”

(Investigations of Failures of Epoxy Polymer Overlays in Missouri / Nov 2007)

**While this deck is considered a poor candidate for a Thin Bonded Polymer Overlay, it is still a good candidate for a PPC, LMC, or MSC Overlay.
(Consider Life Cycle)**



Condition Assessment

Criteria for Thin Bonded Polymer Overlay

- >250psi tensile strength of deck concrete
- <5% of the concrete deck de-bonding from corrosion of steel reinforcing
- Exposure to moisture, de-icing chemicals and freeze/thaw conditions.
- Mild to moderate cracking
- A new bridge deck should have a minimum hydration period of 28 days



Poor Condition for Thin Polymer (MLS)



Concrete with low tensile strength is a poor substrate for a Thin Polymer MLS.

Shear stresses within a compromised substrate will likely lead to the de-bonding of the thin-bonded overlay system.

Potential Failure Mechanisms

Polymer Overlay Systems



- Thermal incompatibility with deck substrate – de-bonding with concrete attached
- Poor surface preparation-de-bonding without concrete attached
- Poor deck condition – de-bonding with concrete attached (spalling affect)
- Improper mix ratio – tacky material that doesn't reach designed properties

Overlay or Deck Replacement

TRIGGER: PPC, LMC, MSC, Low Slump, Rapid Set Overlay

Polyester Polymer Concrete

- Impermeable
- Low Life Cycle Cost
- High Abrasion Resistance
- High Impact Resistance
- Some Structural Capacity

High Performance Concrete

- Low Permeability
- Low Life Cycle Cost
- More Prone to Cracking
- Structural Capacity



Overlay or Deck Replacement

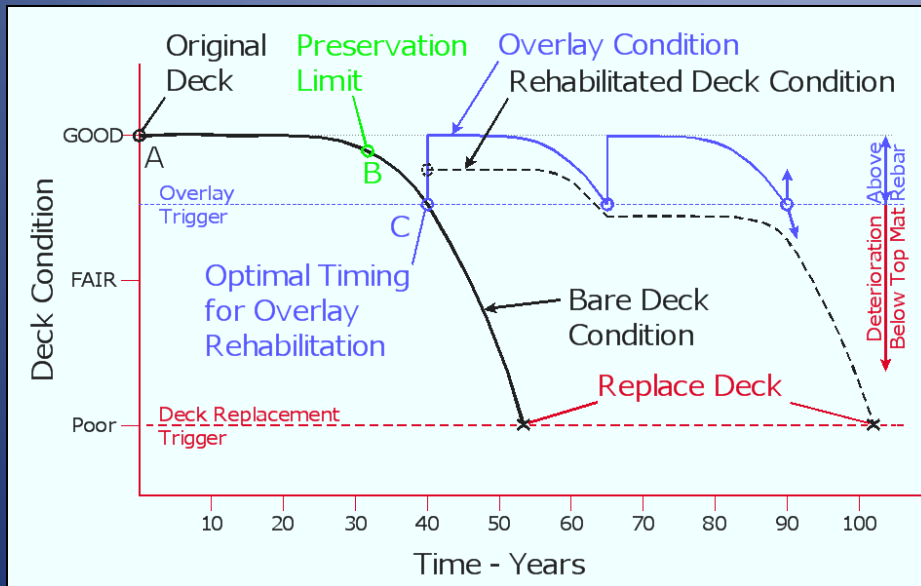
TRIGGER: PPC, LMC, MSC, Low Slump, Rapid Set Overlay



Overlay General Guidelines

- 2%-35% Visual Deck Distress
- Consider critically chloride-contaminated concrete [chloride ion content at the reinforcing bar of 1 lb./yd.³ (0.6 kg/m²) or more, or more half-cell potential of -0.250 V (CSE) or less] should be removed prior to placing a bridge deck treatment”
- Sound substrate under repairs
- Mild to moderate cracking
- Deck surface / ride problems
- Highly permeable concrete deck concrete

Overlay or Deck Replacement?





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