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INNOVATION & RESEARCH

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Preservation, Repair and Rehabilitation of Concrete Bridges, Pavements and Tunnels in Virginia

International Concrete Repair Institute Spring Convention
Reno, Nevada
March 20, 2014

Michael Sprinkel, PE., Associate Director

Preservation Activities

- Washing bridge decks, joints, drains, pier caps, bridge seats
- Crack Sealing
- Concrete Sealing
- Bridge Overlays
- Pavement Overlays

Washing bridge decks, joints, drains, pier caps and bridge seats

- Water: from waterway or nearby fresh source
- Pressure: 1200 – 6000 psi
- Wash water and debris directed toward nearby vegetation, not allowed in waterway

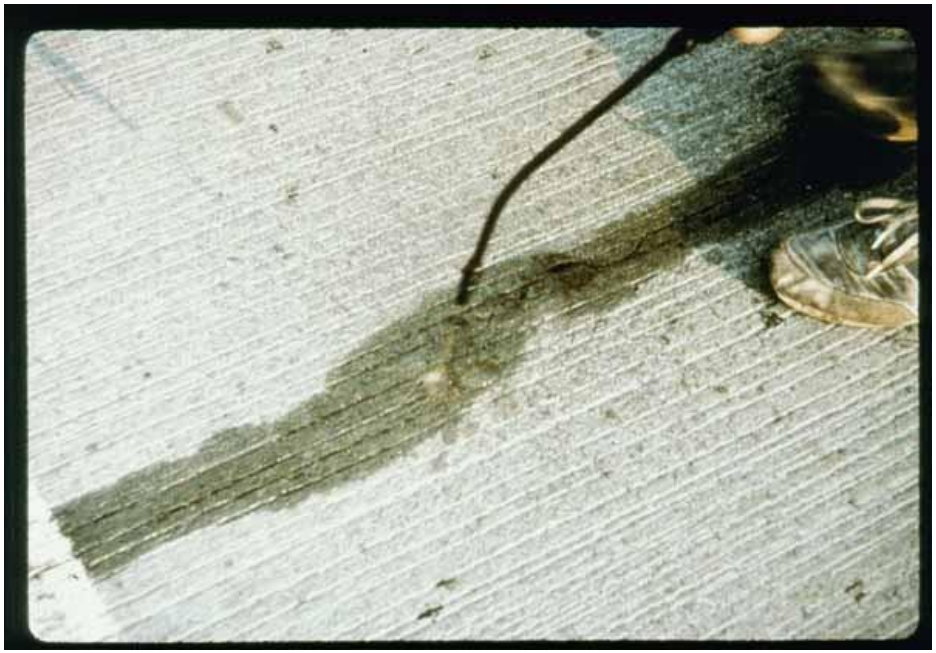
Crack Sealing

- Materials include high molecular weight methacrylate, epoxy and urethane.
- Need to use materials with adequate pot life to penetrate cracks.
- Cure time affected by the condition of the concrete, temperature and relative humidity
- Apply material over deck surface with broom, squeegee or low pressure spray
- Apply sufficient material to fill cracks
- Broom excess material from valleys of texture before it gels
- Treat individual cracks with small batches
- Refer to VDOT Special Provision for Gravity Filled Polymer Crack Sealing and List 28 Polymers for Sealing Cracks, VDOT website: materials/approved _lists)

Crack Sealing

Flooding Surface Application

Individual Crack Application



Concrete Sealing

- Apply sealer with broom, squeegee or low pressure spray
- Refer to List 30 Sealants, Stains and Coatings, VDOT website: materials/approved _lists)
- Additional information:

  Maine DOT approved products list, concrete sealers

  NCHRP Synthesis 209 Sealers for Portland Cement Concrete Highway Facilities

Concrete Sealing

- Water repellents such as silanes and siloxanes typically cure faster
- Pore blockers such as acrylics, linseed oil, epoxy, polyester, gum resin and urethane typically cure slower
- Cure time affected by the condition of the concrete, temperature and relative humidity

Concrete Sealing

Bridge Overlays

- Epoxy
- Concrete
  - Latex-modified (LMC)
  - LMC very early (LMC-VE)
  - Silica Fume
  - Hydraulic Cement Concrete (HCC)

Multiple Layer Epoxy Overlays

3 hour cure time (depends on temperature)

2 layers of epoxy and broadcasted aggregate, 0.25-in thick

(Refer to VDOT Special Provision for Epoxy Concrete Overlays)

Shot blasting surface

Placing epoxy prior to broadcasting aggregate

Epoxy overlays

I64 Virginia

Mission Bay San Diego

LaGuardia Runway

HCC Overlay Options

3 to 7 day cure time (conventional repair)

- 15 % latex and type I/II cement (LMC)
- 7 % silica fume and type I/II cement (SF)
- 15 % latex and type K cement (LMC-K)
- Other HCC overlays have been used

24 hour cure time (early repair)

- 15 % latex and type III cement (LMC-HE)
- 7 % silica fume and type I/II cement (SF)

3 hour cure time (very early repair)

- 15 % latex and calcium sulfoaluminate and dicalcium silicate cement (LMC-VE)

Concrete removal and surface preparation

Milling rapidly removes the old surface

Shot blasting cleans and prepares the surface

Polyethylene protects prepared deck surface, screed consolidates and strikes-off overlay, wet burlap and polyethylene cures overlay

Construction of LMC-VE Overlay, 1998
Fogging to minimize cracking.

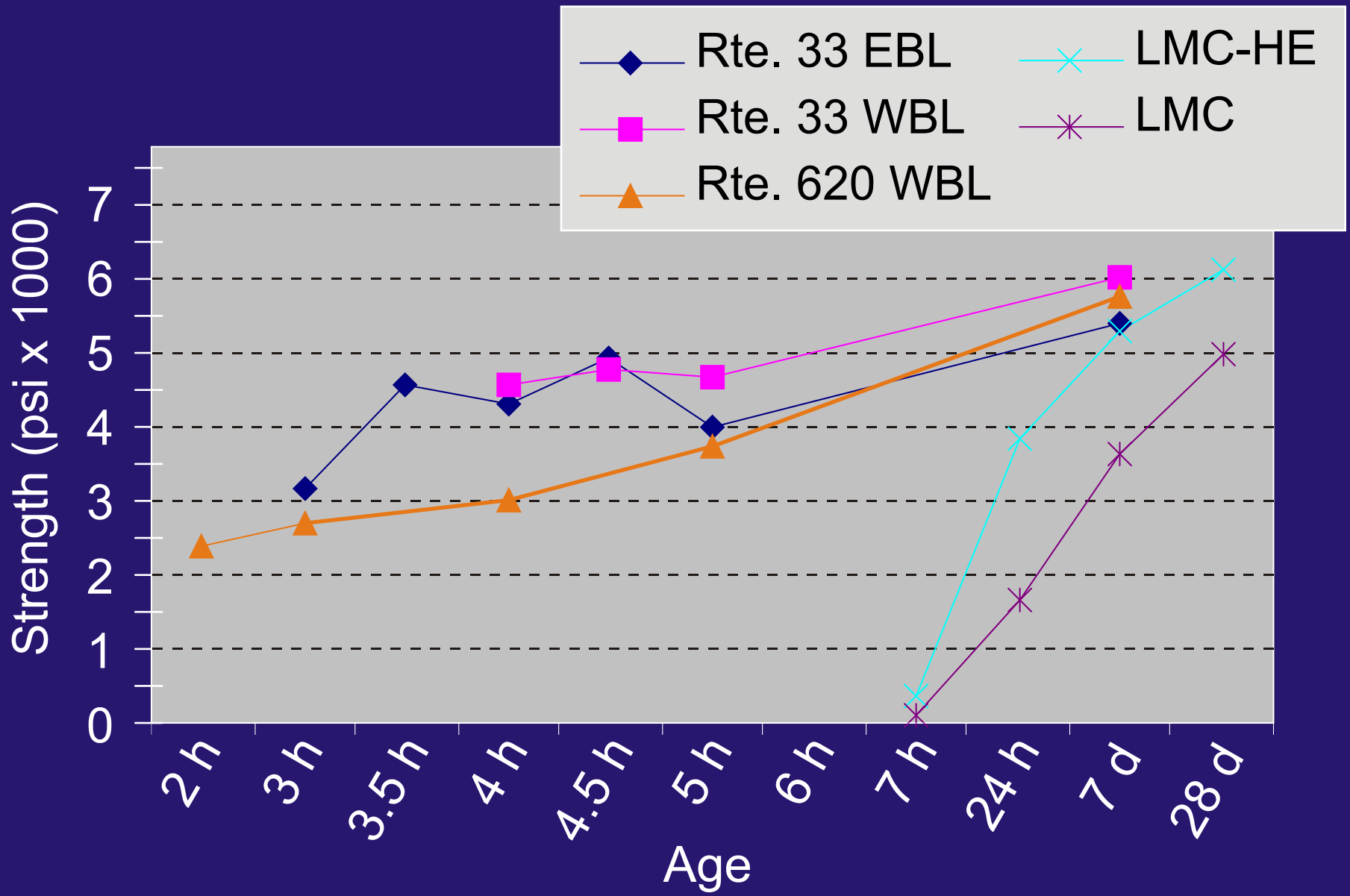
Typical Mixture Proportions, lb/yd3

Mixture	LMC	LMC-K	LMC-HE	SF	LMC-VE
Cure Time	3 day	3 day	24 hr	24 hr	3 hr
Cement	I/II	K	III	I/II	Rapid Set
Cement	658	658	815	658	658
Silica Fume	0	0	0	46	0
Fine agg.	1571	1544	1402	1269	1600
Coarse agg.	1234	1208	1142	1516	1168
Latex (48%)	205	205	218	0	205
Water	137	137	164	282	137
Air, per cent	5	5	5	7	5

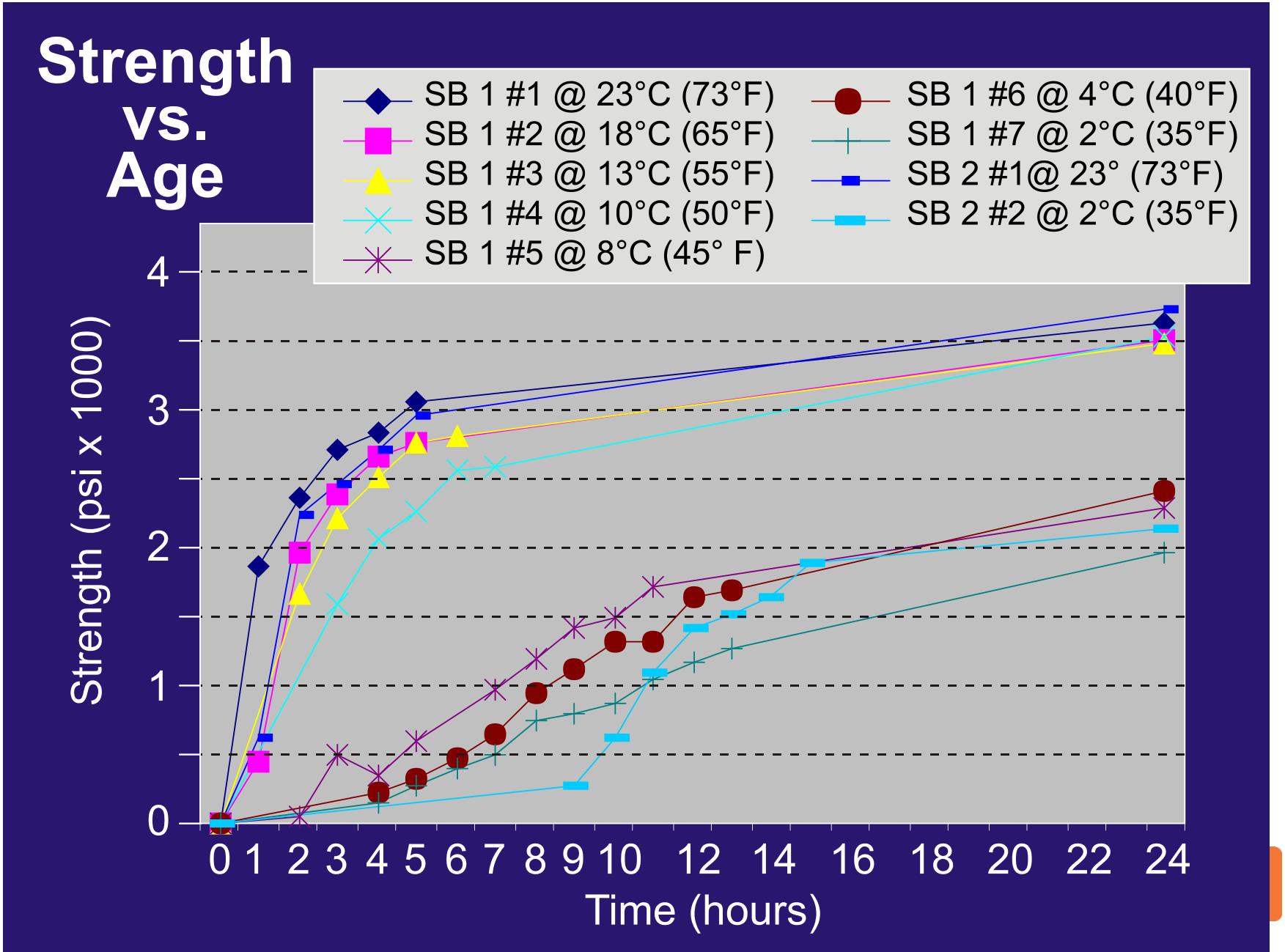
Average Compressive Strength, lb/in2

Mixture	LMC	LMC-K	LMC-HE	SF	LMC-VE
Cure Time	3 day	3 day	24 hr	24 hr	3 hr
3 hr.	-	-	-	-	3510
4 hr.	-	-	-	-	3810
5 hr.	-	-	-	-	4070
24 hr.	1810	1680	3600	2520	5440
7 day	3360	4220	4940	5310	6290
28 day	4630	5880	5700	7250	6710

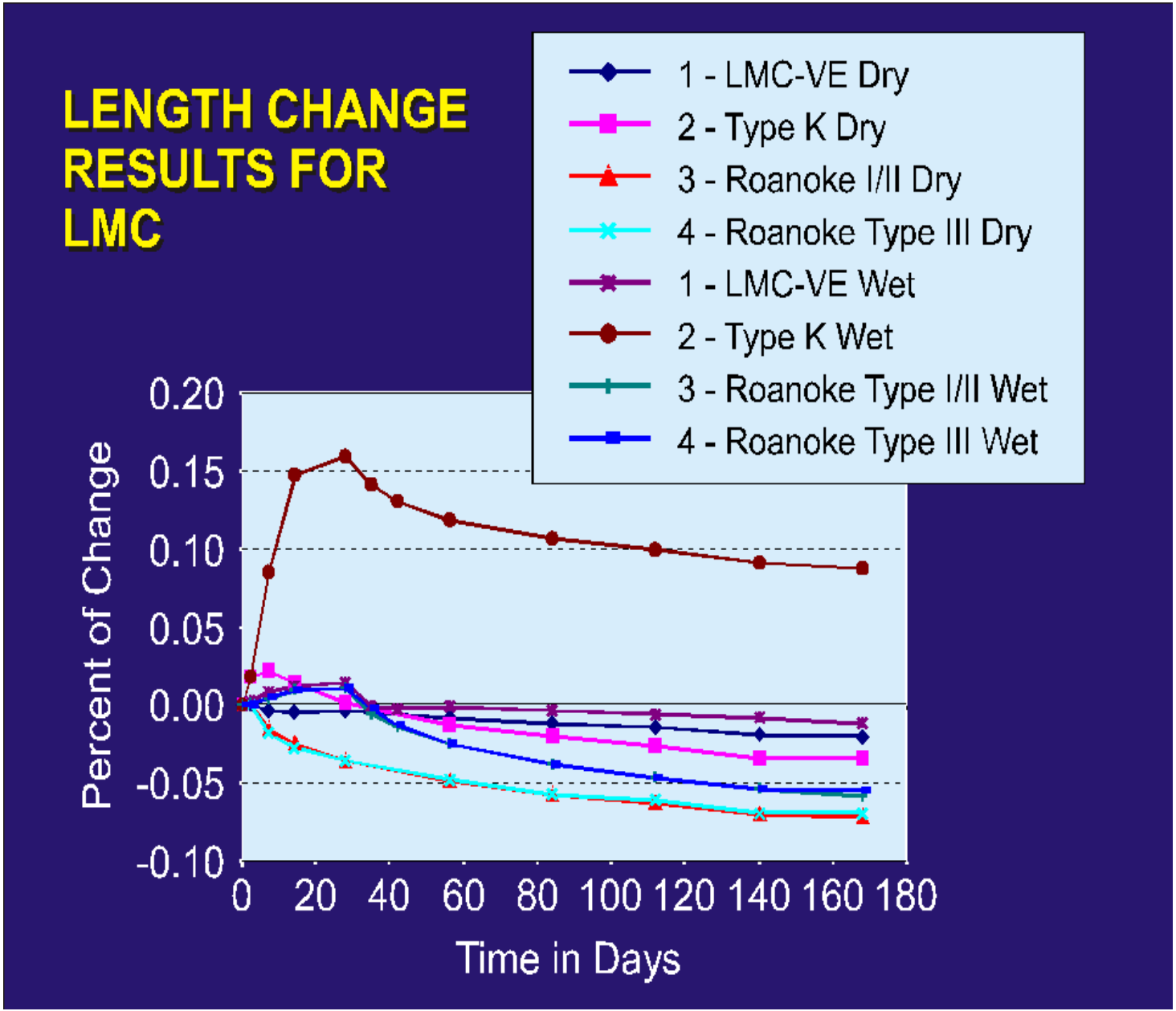
Comparative Strength vs. Age



Effect of temperature on LMC-VE strength



Drying Shrinkage, ASTM C157



LMC-VE Overlays

1st overlay: US 33,1997, 3 lane spans per night
2nd overlay: Braddock Rd,1998, 3 lanes 4 nights

2006: I64, two long weekends, 5000yd2, Construction $750,000, Road User savings $520,000, Use of LMC-VE overlays increasing

Ref: TRR 1668, 1999; TR News 247, 2006

LMC-VE Overlays

LMC-VE overlays constructed with the same specification: badly cracked (left), crack free (below). Following the specification makes the difference.

Concrete Pavement Overlays

- HCC
  - Bonded (surface preparation by shot blasting)
  - Unbonded (1-in thick asphalt separation layer)
- Concrete Pavement Overlays for extending the life of CRCP demonstrated (two 1000-ft sections) in 1995.
- Larger project (4.8 miles) constructed in 2012 (after 17 years of good performance).
- Larger project allowing HCC and Stone Matrix Asphalt as alternatives to be advertised in 2014 (after 19 years).

(Ref: VTRC 99-IR3, VTRC 01-R2, TRB 14-2776)

Concrete Pavement Overlays

4-in bonded overlay placed on I85 in 1995 2-in bonded overlay placed on I295 in 1995

US 58 4-in bonded overlay and 7-in unbonded overlay placed in 2012

Repair and Rehabilitation Activities

- Crack repairs in Bridges and Tunnels
- Bridge and Pavement Patching
- Joint repairs in Bridges and Pavements
- Cathodic protection of bridge substructures
- Replacing Tendons in Post-tensioned Bridges
- Removing Ceiling panels in Tunnels

Crack Repairs in Bridges

Full Depth Transverse Cracks in High Performance Concrete Decks

Crack Repairs in Bridges

Carbon Fiber Mesh
Epoxy overlay

Pressure
Injection

Route and
Gravity Fill

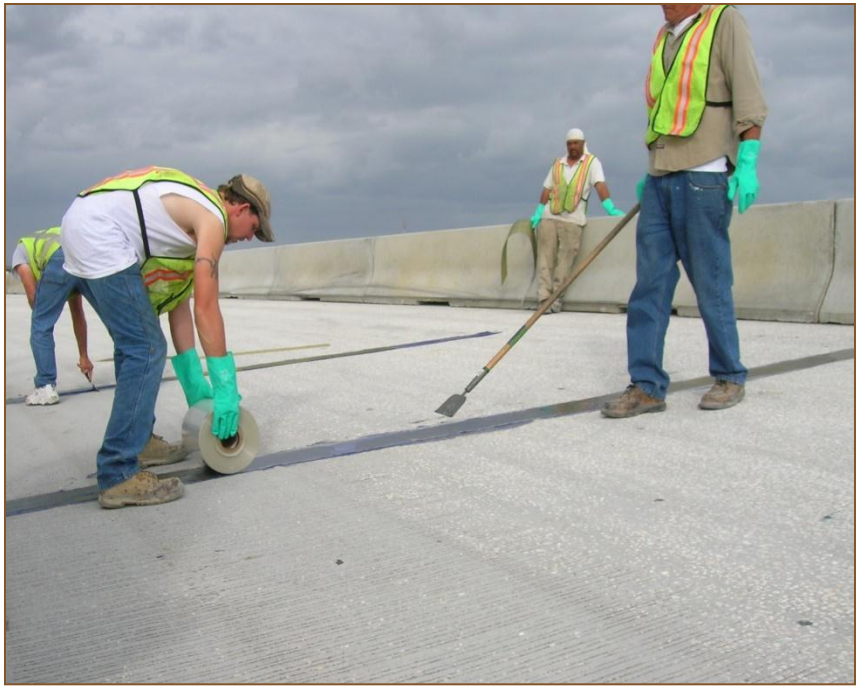
Filling Cracks with Gravity Fill Polymer

0.75 mm wide crack filled with HMWM

Kevlar Carbon Fiber Sheet

- Shot blast surface along crack
- Mix and place epoxy along crack
- Roll Kevlar carbon fiber sheet, centered over crack, onto epoxy
- Press sheet into epoxy
- Broadcast aggregate into epoxy

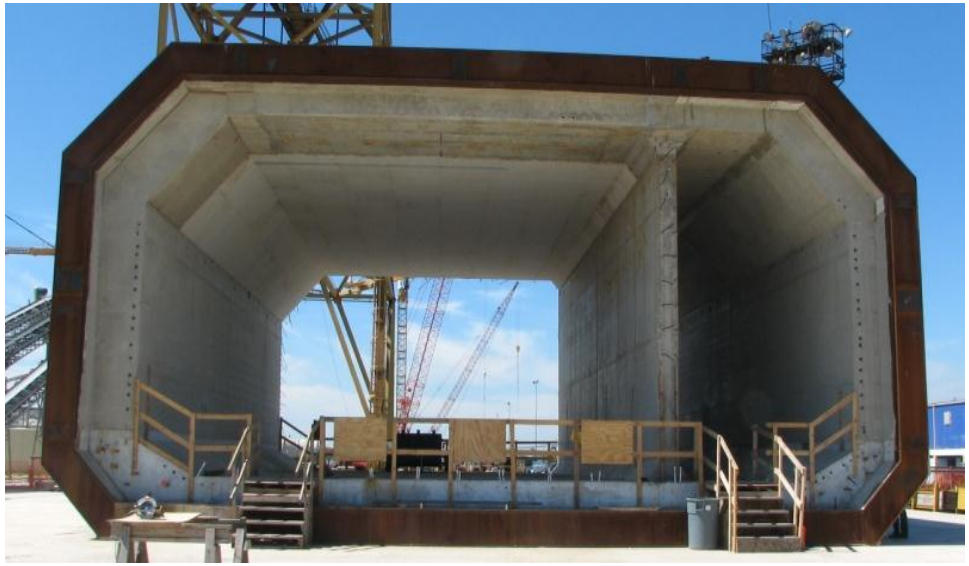
Application of Fortress 4020 LPL/Kevlar Carbon Fiber Sheet

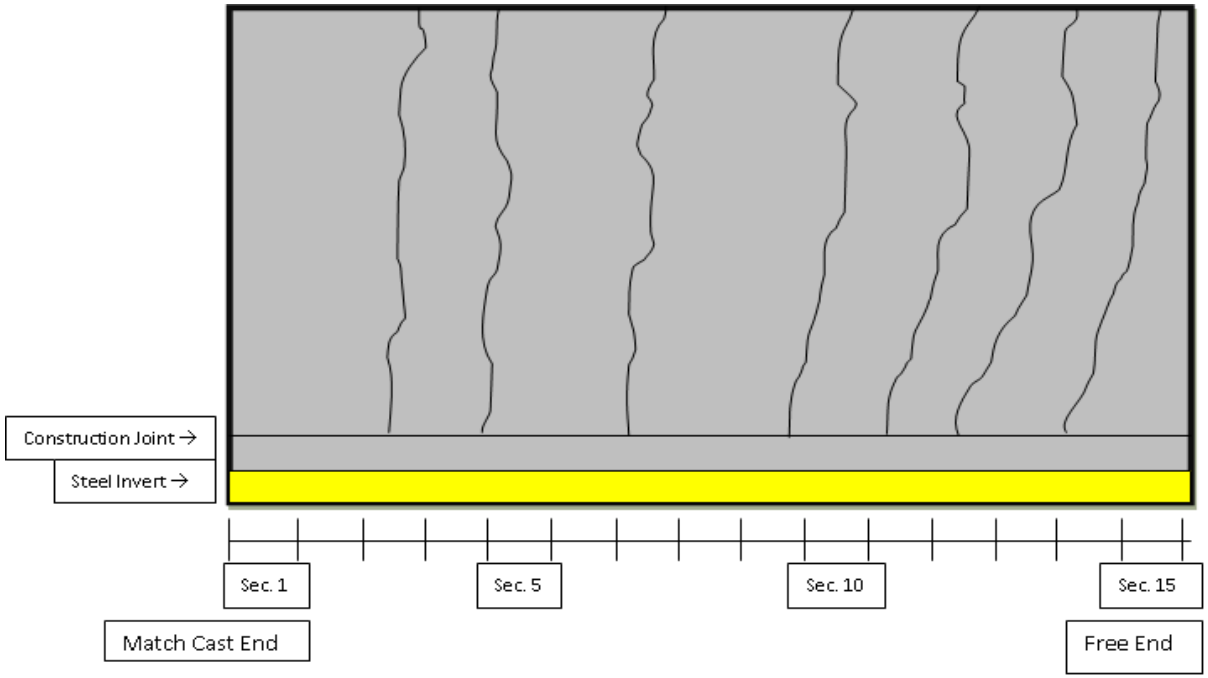


Pressure Injection of Epoxy

Paste type epoxy is applied to the top and bottom of the crack. Epoxy is injected from port to port.

Crack Repairs in HPC Tunnel Segments



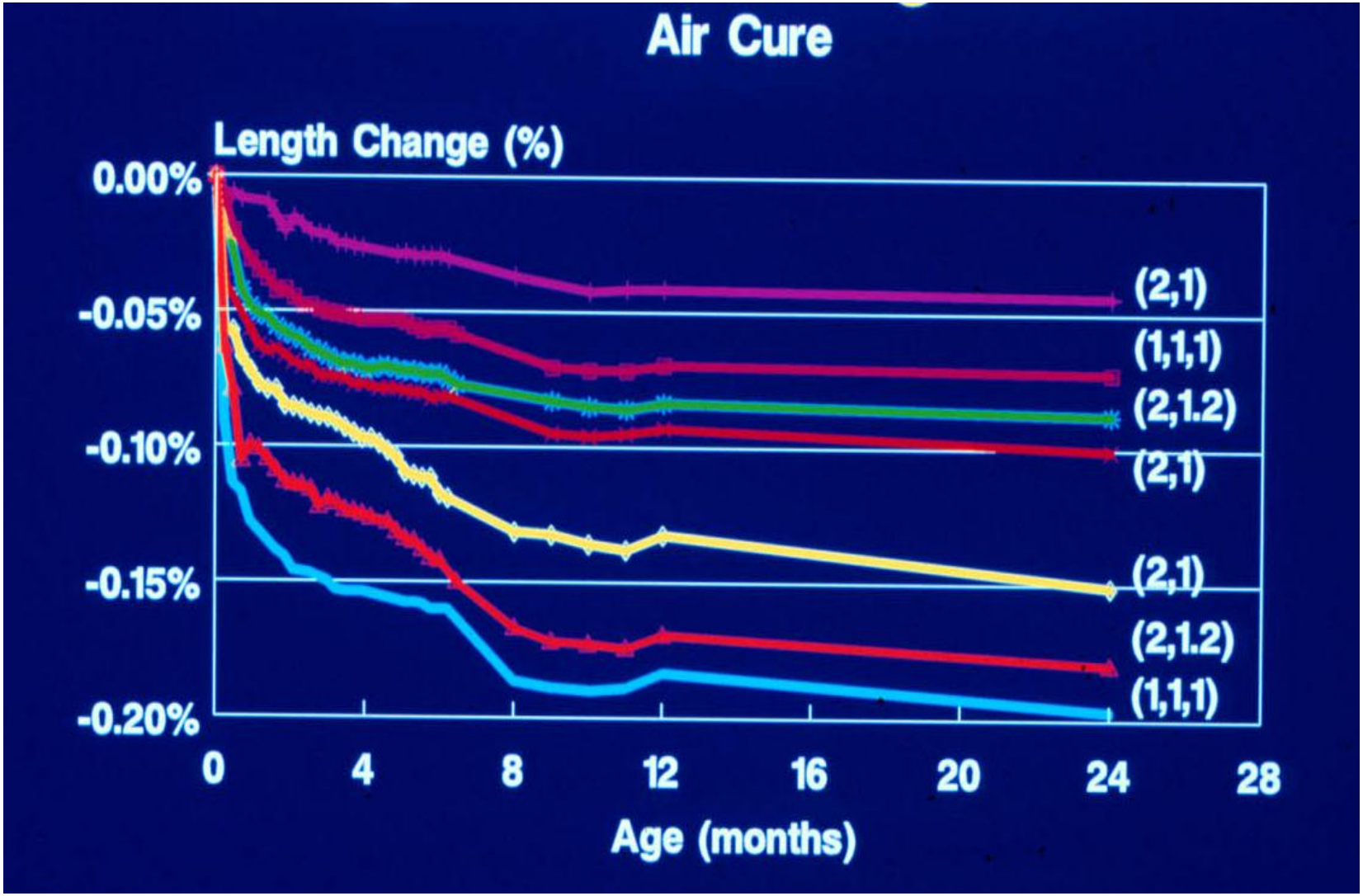


0.45-mm wide Crack in 3-ft thick Segment wall

Pressure Injection Repair

Bridge Patching

Bridge Deck Patching



Bridge Deck Patching

- Refer to List 31,HCC Patching Materials, VDOT website: materials/app. _lists for products that achieve 2500 psi comp. strength in ≤ 2 hours.
- Sawcut perimeter 1 inch deep
- Remove concrete using hammers weighing < 30 lbs

Full Depth Patching Required for Deck Failure on I81 in 2009 after 17 years. Leaking Construction Joint Subjects Epoxy Coated Rebar to Chlorides and Moisture

Self Consolidating Concrete Repairs

Ref: Celik Ozyildirim Ph.D., P.E.

Slump test

SCC

Slump flow

SCC placement using pump to patch pier cap I81

SCC versus Shotcrete

SCC Smooth surface

Shotcrete Rough surface

SCC Pier Cap Repairs

Ref: Celik Ozyildirim Ph.D., P.E.

Altavista, VA

NOVA, I-95 over Furnace Road

Completed pier cap

Joint Repairs in Bridges and Pavements

Joint repairs in Bridges

Styrofoam is used to form the joint opening and List 31 polymer concrete is placed to construct the headers

Joint Repairs in Bridges

Two component silicone mixed in the nozzle is used to caulk a joint rapidly

Joint Replacement

Joint and header replacement require major effort: removal of concrete and installation of rebar, header, concrete and joint.

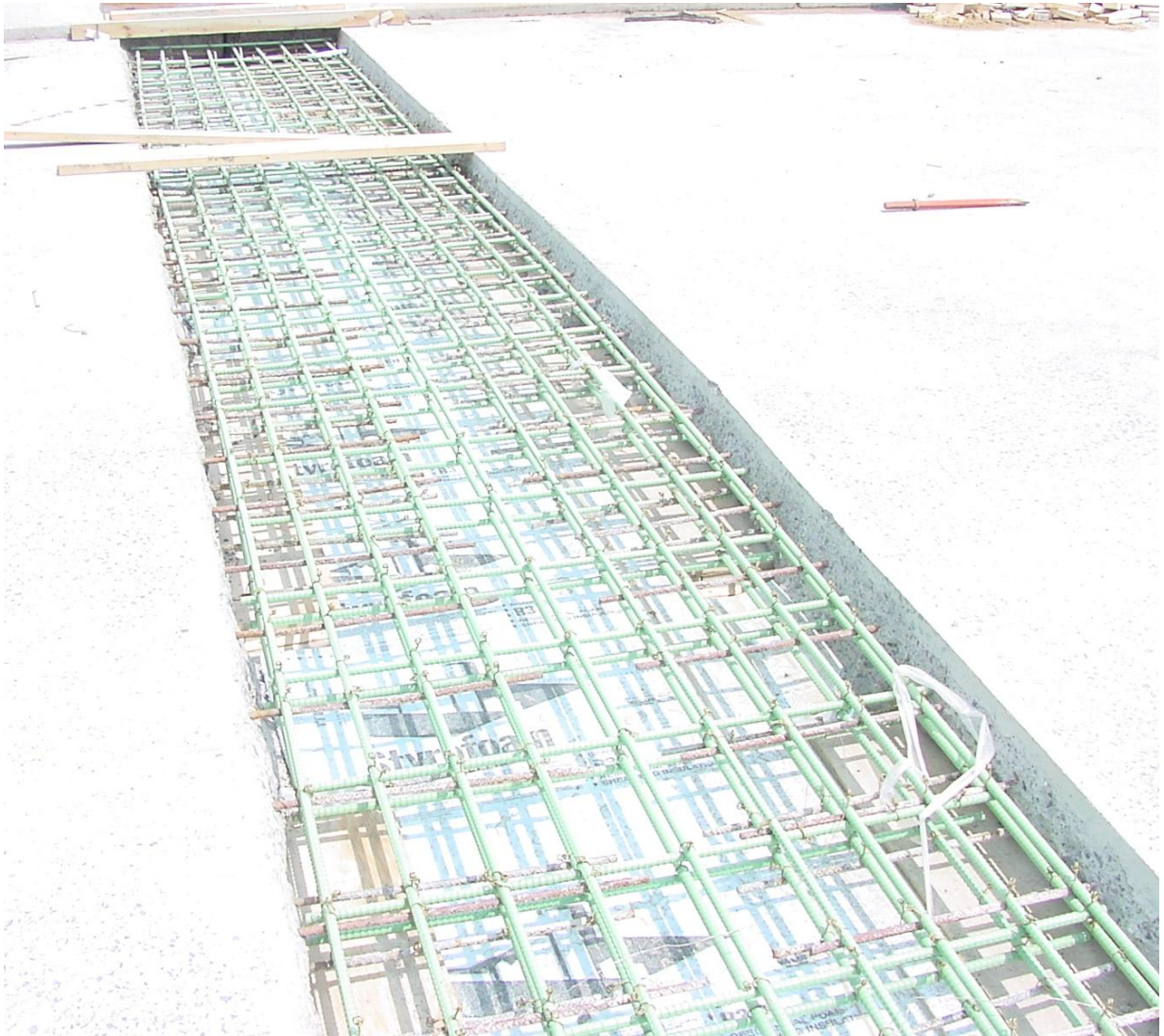
Joint Elimination Reduces Maintenance Costs
(over piers and abutments)

- Remove joint and concrete
- Form area
- Place 0.5-in neoprene pad over beams
- Place reinforcement
- Place concrete

Joint Elimination

Joint and concrete removed from deck and parapet for joint closure.

Joint Elimination

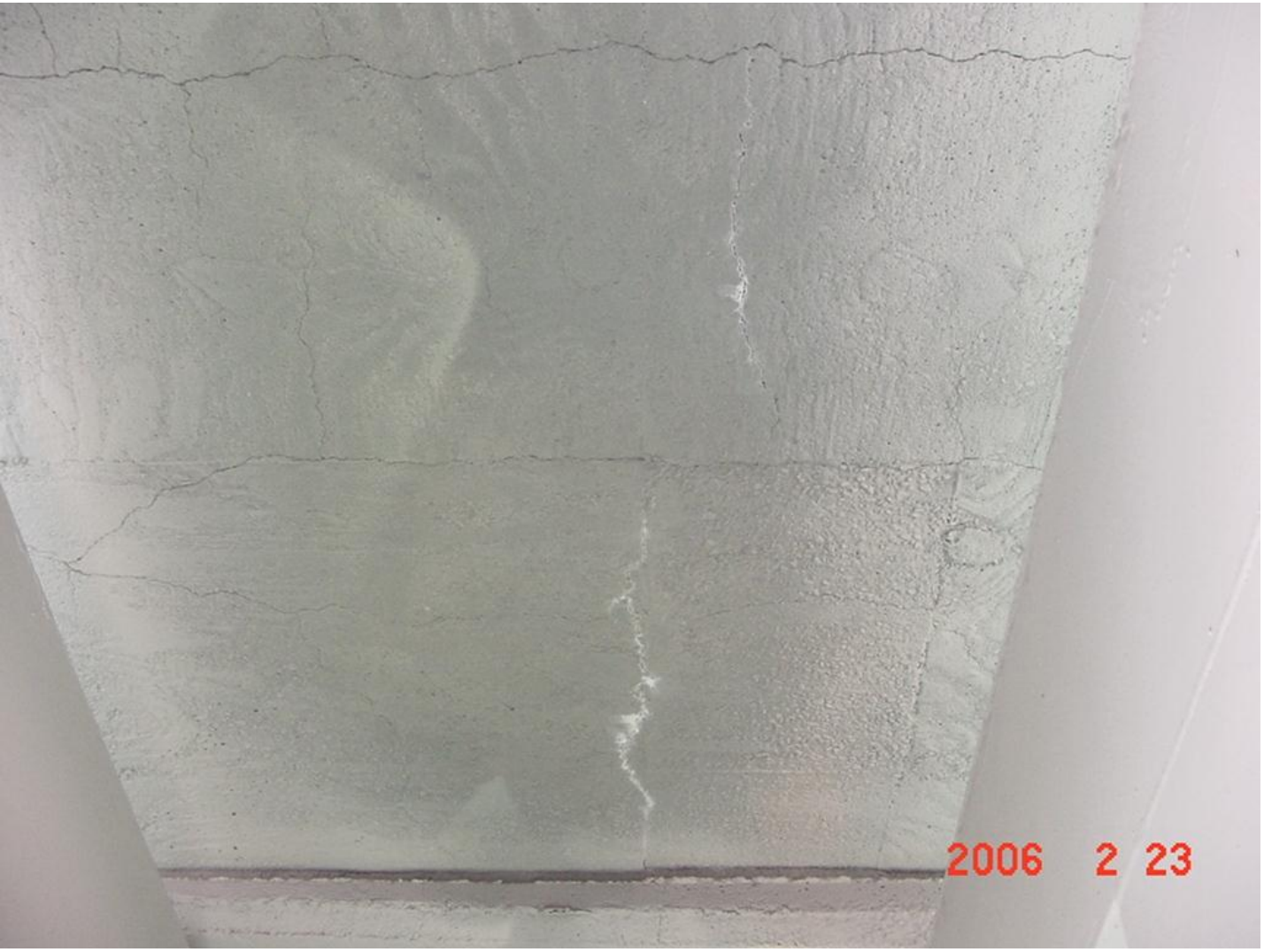


Formwork and reinforcement in place for joint closure concrete.

Joint Elimination

Cracks and joints in joint closure concrete have been sealed with gravity fill epoxy.

Joint Closure

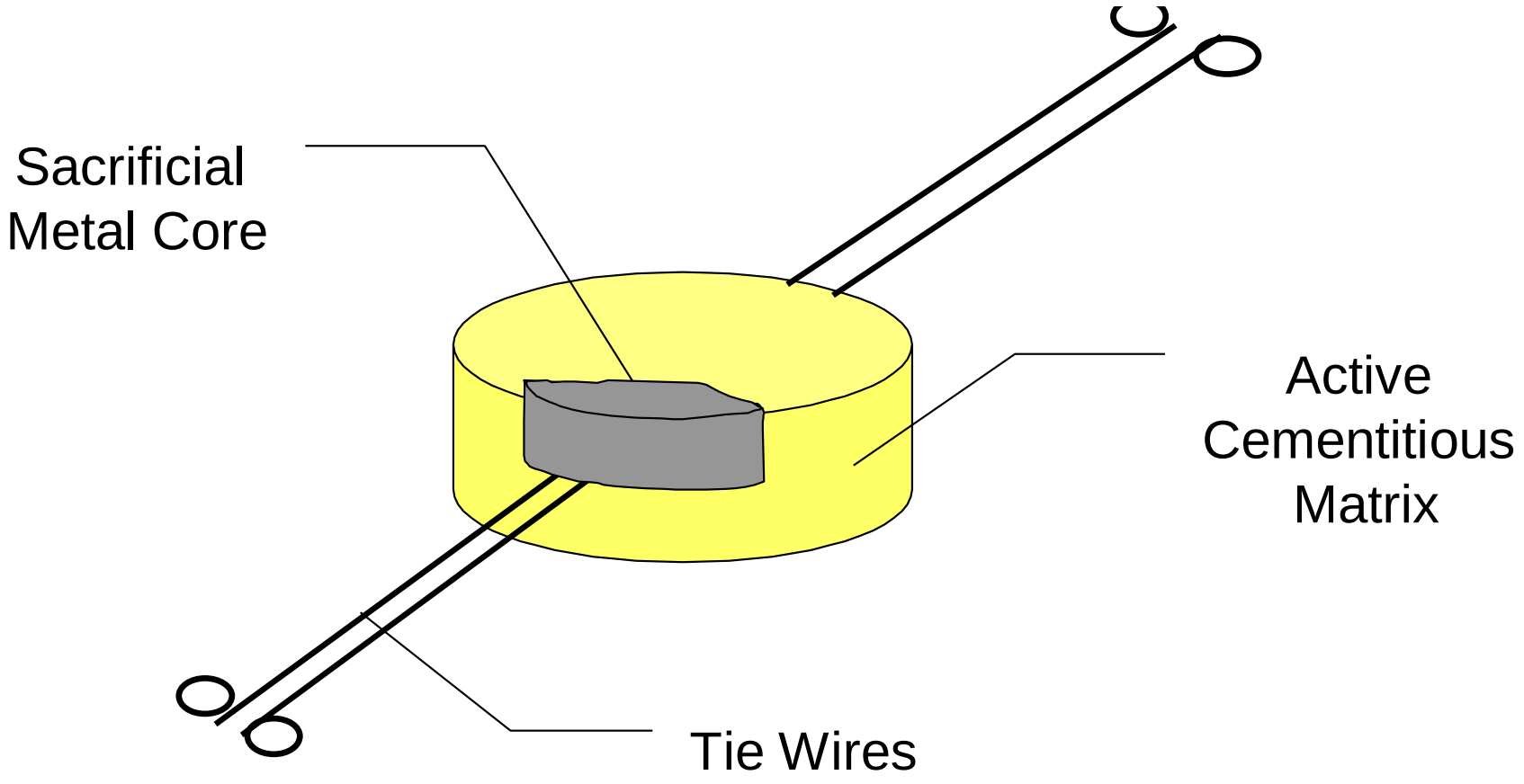


Bottom view of joint elimination showing 0.5-in thick neoprene pad over beam.

Cathodic Protection of Bridge Substructures

Sacrificial Zinc Anode
applied to piers and bent provides

Galvanic Anode to Prevent Ring Corrosion



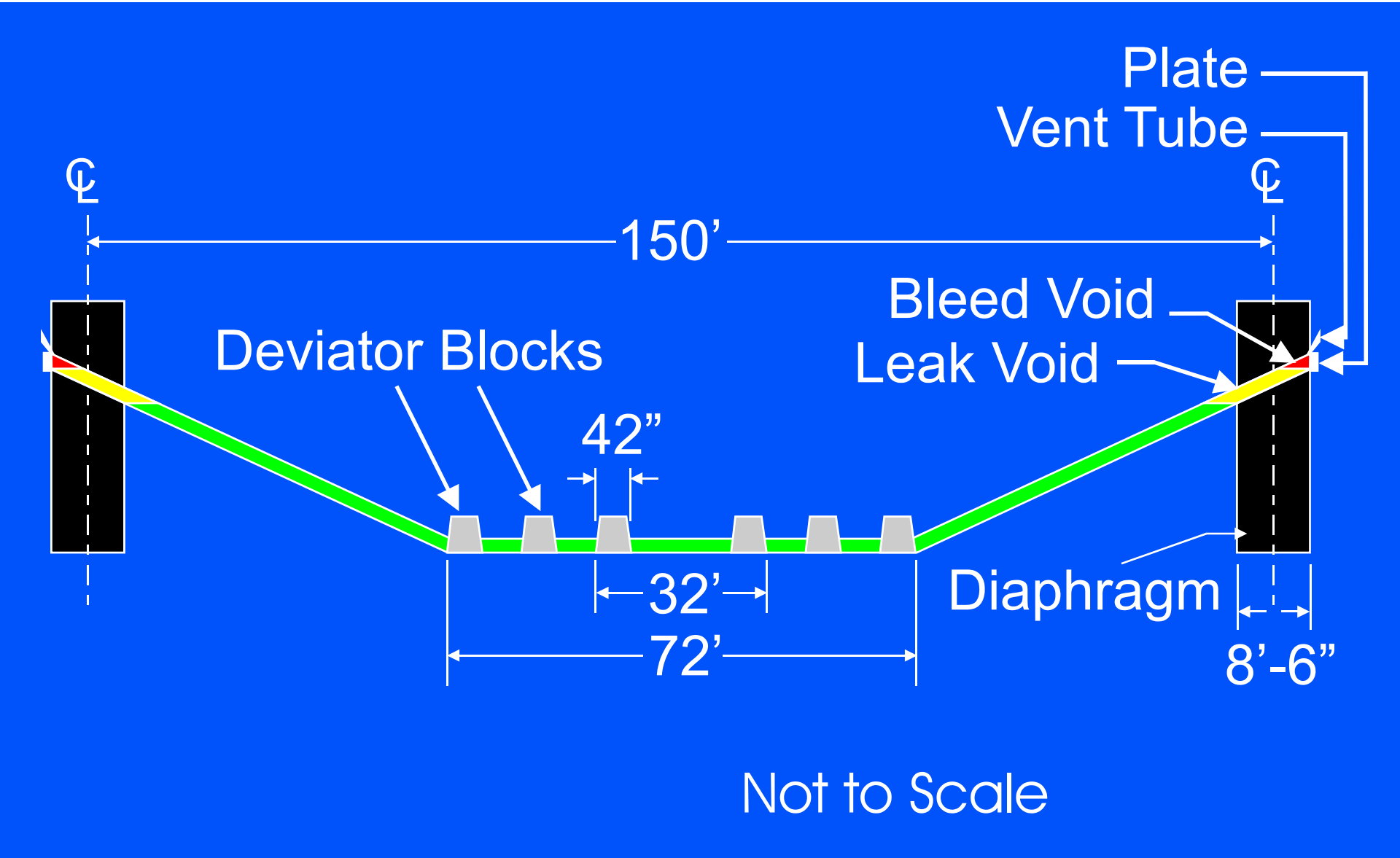
Galvanic anodes are tied to the top rebar along the perimeter of the area to be patched.

Deck Patch

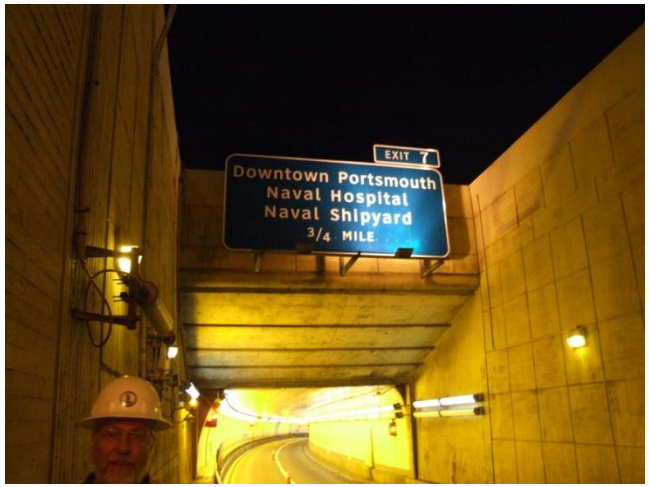
Replacing Tendons in Post-tensioned Bridges

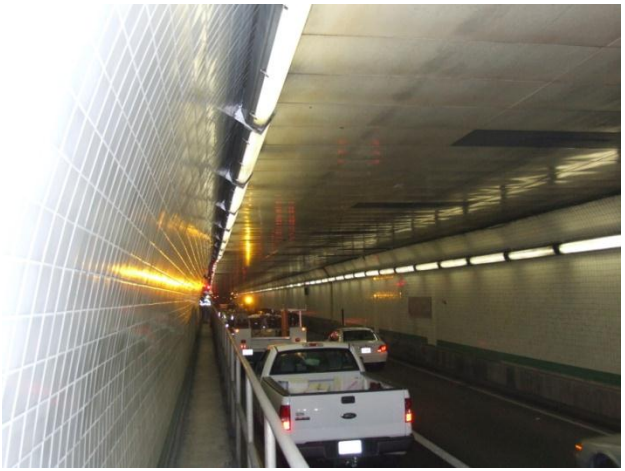
Tendon Failure in 2007 after 17 years

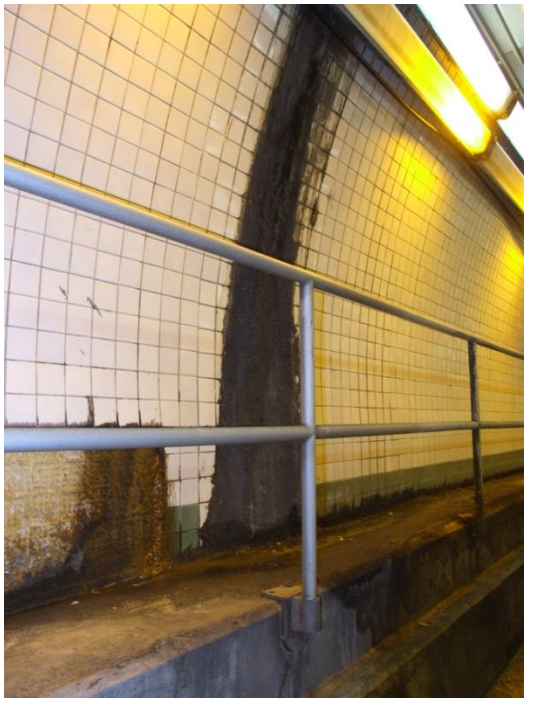
Typical Tendon Span



Removing Ceiling Panels in Tunnels







Removing Ceiling Panels in Tunnels

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Questions ?

For more information:

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