

WILLIAM VERMES, PE
NOVEMBER 10, 2016




**PERFORMANCE OF OHIO'S
CONCRETE ARCH BRIDGE
REHABILITATION**

INTERNATIONAL
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2016 Fall Convention | November 9-11 | Cleveland, Ohio

Why?



CEDAR POINT ROAD BRIDGE

- 86-YEARS OLD
- HISTORIC BRIDGE IN A PARK SETTING




**OWNER:
PREFERS REHAB W/ 75-YEAR
ADDED SERVICE LIFE**

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Why?



ODOT:

- 12 DISTRICTS
- 1-CENTRAL OFFICE
- 13 OPINIONS
- 7 DISTRICTS HAVE USED CATHODIC PROTECTION

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What the Bridge Owner Wants

GRADE	DESCRIPTION
9	Excellent
8	Very Good
7	Good
6	Satisfactory
5	Fair
4	Poor
3	Serious
2	Critical
1	Imminent Failure
0	Failure

**FHWA/NHI BRIDGE
CONDITION RATING SCALE**


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Concrete Bridges – A Historical Perspective of Durability

ADVANTAGES OF CONCRETE BRIDGES

Concrete bridges are permanent improvements.
Concrete bridges require neither painting nor repairs.
Concrete bridges have no wooden decks that are periodically out of repair.
As time passes, traffic on our highways grows heavier, steel and wooden bridges grow weaker, concrete bridges grow stronger. To build a concrete bridge, there is just plain common sense.
Concrete bridges are flood-proof and fire-proof, non-pollut and fire-proof.
A concrete bridge once built, is built for all time.
A concrete bridge is the only bridge that grows stronger as it grows older.
Concrete arch bridges are readily adapted to soil foundations.
Concrete bridges are built with honest labor and materials. The money expended for a concrete bridge returns directly to the taxpayer.



Concrete bridges are permanent improvements.
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Concrete Bridges – A Historical Perspective of Durability

JOURNAL
OF
AMERICAN CONCRETE
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Concrete: Its Maintenance and Repair*

By R. S. Taylor

Extensive concrete is mentioned nowhere in the treatment of... Before concrete can be properly prepared, the work is to be designed and before an accurate diagnosis is possible, the doctor has to have a thorough knowledge of disease, the nature, symptoms and treatment. The concrete doctor, in the field, needs similar knowledge of the conditions that he encounters in actual construction and maintenance. There are many examples of deterioration that should be noted and avoided in existing concrete. I. e., handling, curing and how... (The text continues with technical details about concrete maintenance.)




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**Concrete Bridges –
A Historical Perspective of Durability**


**NORTH HILLS VIADUCT
AKRON, OHIO
1922-1977**



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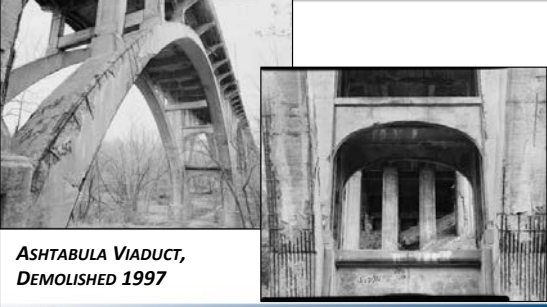
**Concrete Bridges –
A Historical Perspective of Durability**

ASHTABULA VIADUCT, OPENED 1922



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**Concrete Bridges –
A Historical Perspective of Durability**




**ASHTABULA VIADUCT,
DEMOLISHED 1997**

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**Ohio's Conventional
Concrete Arch Rehabilitation –
1980s to 2010**

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**Brookpark Road Viaduct Rehabilitation,
1987-88**



- OPENED 1936
- PARK SETTING



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**Brookpark Road Viaduct Rehabilitation,
1987-88**

ELEMENT OF STRUCTURE	TYPE OF REINFORCEMENT SYMBOL	SCALE	SUMMARY OF QUANTITIES														
			SPALL		DEFORMATION WRENCH		WELDED FABRIC		PATTERN CASTING		CRACK		CORNER CHAIR		POPCOTS		HONEYCOMB
			S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.	S.F.
WEST APPROACH																	
SPANS																	
EAST APPROACH																	
TOTAL																	

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GENERAL NOTES - STRUCTURE REPAIR

INVENTORY OF DETERIORATION - THESE PLANS, SHEETS S1 THRU S2 PRESENT AN INVENTORY OF THE DETERIORATION PRESENT ON THE BROOKPARK ROAD BRIDGE OVER RIVER BY TYPE AND EXTENT. THE INVENTORY WAS PERFORMED BETWEEN MAY 22 AND JUNE 23, 1978 AND WAS RE-INVENTORIED FEBRUARY 1986.

THE ORIGINAL INVENTORY WAS OF THE TOTAL STRUCTURE BUT AS IS INDICATED ON THE PLANS, PORTIONS OF THE STRUCTURE WILL BE REMOVED FOR THE WIDENING PART OF THE REHABILITATION PROJECT AND WILL NOT REQUIRE REPAIR. THE RE-INVENTORY WAS RESTRICTED TO THOSE PORTIONS OF THE STRUCTURE TO REMAIN AFTER REMOVAL OPERATIONS.

THE QUANTITIES LISTED IN THE SUMMARY OF QUANTITIES SHEET S1 ARE THE ESTIMATED AMOUNT OF THE VARIOUS TYPE OF REPAIR REQUIRED TO REHABILITATE THE STRUCTURE AND DO NOT INCLUDE THOSE AREAS TO BE REMOVED. THESE QUANTITIES ARE BASED ON VISUAL INSPECTION OF THE EXISTING STRUCTURE AND ARE NOT TO BE CONSIDERED TO REPRESENT THE EXACT AMOUNT OF REPAIR REQUIRED TO REHABILITATE THE BRIDGE. PAYMENT WILL BE BASED ON THE ACTUAL WORK PERFORMED AT THE UNIT.

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Brookpark Road Viaduct Rehabilitation, 1987-88

CONSTRUCTION BUDGE: \$3 MILLION

FINAL CONSTRUCTION COST: \$9 MILLION

“WE COULD HAVE GOT A NEW BRIDGE FOR \$12 MILLION!”

- ODOT RESIDENT ENGINEER -

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Brookpark Road Viaduct, 2016

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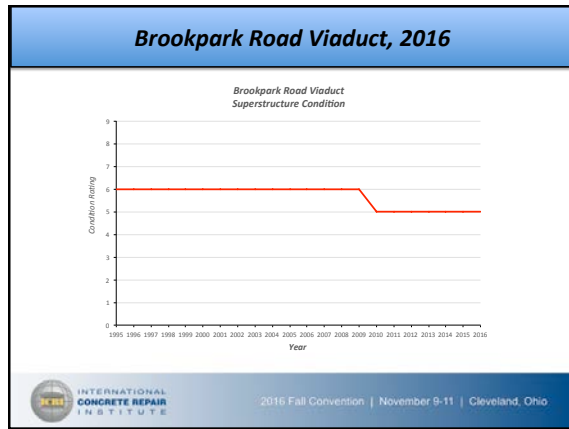


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Brookpark Road Viaduct, 2016



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Brookpark Road Viaduct, 2016



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Cleveland's Detroit-Superior Bridge, 1917

ONE OF CLEVELAND'S ICONS



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Detroit-Superior Bridge Rehabilitation, 1995-97

Member	Total Members	Members Replaced	Total Percent Replaced
Upper Deck Floor Beams	686	316	38%
Upper Deck Columns	693	179	26%
Upper Deck Jack Arches	564	260	45%
Lower Deck Floor Beams	548	50.5	11%
Lower Deck Corbels	279	79	28%
Lower Deck Jack Arches	520	176	34%
Lower Deck Columns	488	8	2%
Upper Exterior Pier Shafts	32	17.5	55%
Lower Exterior Pier Shafts	28	5.5	20%

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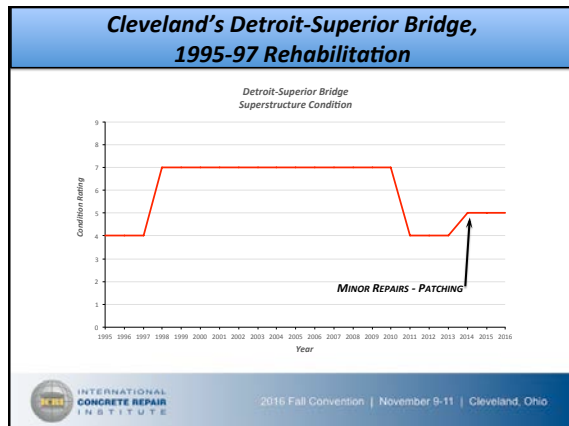
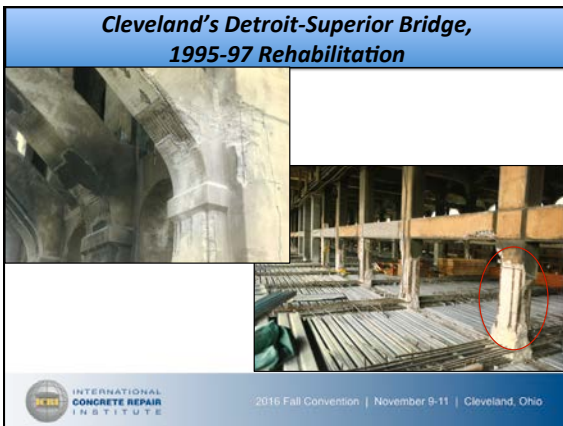
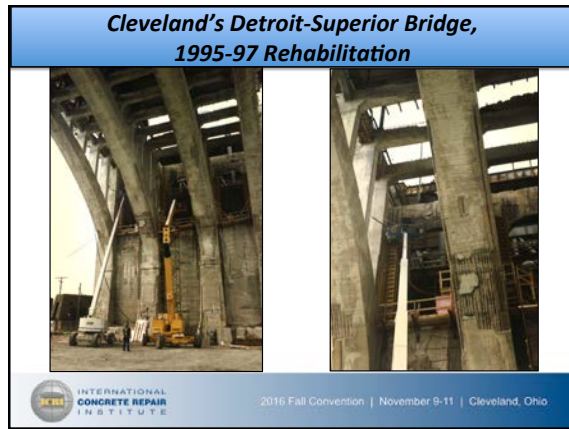
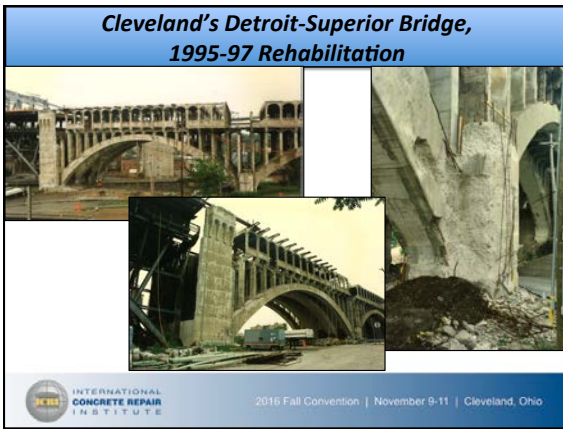
Cleveland's Detroit-Superior Bridge, 1995-97 Rehabilitation

GENERAL OPINION: PATCHES ONLY LAST 10 YEARS!

REVISED PATCHING STRATEGIES USED:

- SAWCUT EDGES
- SHOTCRETE – HIGH QUALITY CONTROL, LOW PERMEABILITY MIXES.

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Ohio Patching of Spalls

GENERAL OPINION: STILL PATCHES ARE TEMPORARY!

NEXT REVISED PATCHING STRATEGIES USED:

- **POURED-IN-PLACE PATCHES PREFERRED**
- **2005: STAINLESS STEEL HOOKED DOWELS**




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Ohio Patching of Spalls

**STAINLESS STEEL HOOKED DOWELS
(ANCHOR THOSE PATCHES)**


ANCHOR/WIRE MESH DETAIL (TYP.)
(EXISTING REINFORCEMENT NOT SHOWN FOR CLARITY) (NOT TO SCALE)



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Cathodic Protection & Ohio's Bridges, 1993 - Present




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I-90 Bridge Decks Rehabilitation, 1993



- **I-90 OVERPASSES BUILT IN 1960S**
- **WEARING SURFACE REPLACEMENT AFTER 30 YEARS**
- **CATHODIC PROTECTION: INSTALLED TITANIUM MESH WITH IMPRESSED CURRENT.**



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I-90 Bridge Decks Rehabilitation, 1993

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SEPARATION BETWEEN ZONES

REFERENCE CELL DETAIL (TOP VIEW OF CELL)

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I-90 Bridge Decks Rehabilitation, 1993

PLAN

TRANSVERSE SECTION

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I-90 Bridge Decks Rehabilitation, 1993

COLUMBIA ROAD OVER I-90

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I-90 Bridge Decks Rehabilitation, 1993

A GOOD WEARING SURFACE MEANS A GOOD DECK.

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I-90 Bridge Decks Rehabilitation, 1993



ALL IMPRESSED CURRENT SYSTEMS WERE POWERED DOWN IN 2013. CONDITION IS BEING MONITORED CLOSELY.

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Jefferson Street Bridge, Fairmont, West Virginia (1922)



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Jefferson Street Bridge, Fairmont, West Virginia Rehabilitated 2001



ALL CONCRETE STRUCTURE WAS REMOVED DOWN TO ARCH RIBS.

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Jefferson Street Bridge, Fairmont, West Virginia Rehabilitated 2001



TITANIUM MESH CATHODIC PROTECTION PLACE ON PERIMETER OF ALL ARCH SURFACES.

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Jefferson Street Bridge, Fairmont, West Virginia Rehabilitated 2001



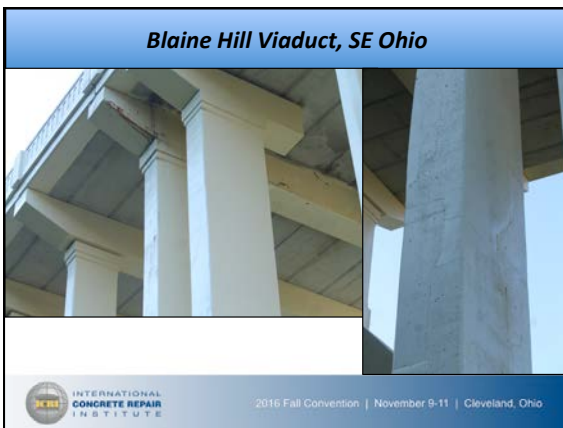
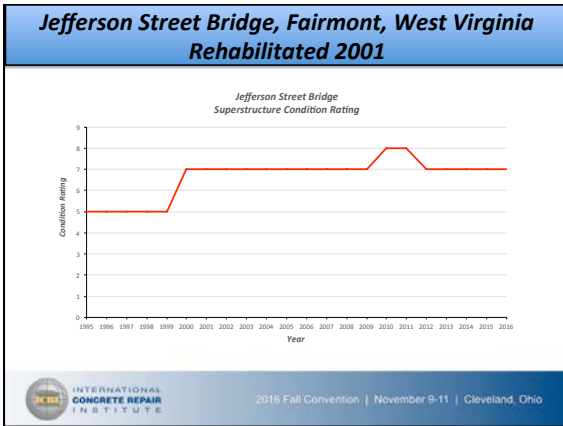
NO CORROSION, NO EFFLORESCENCE.

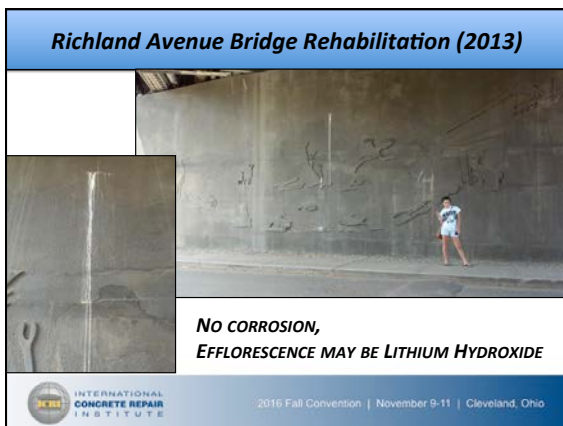
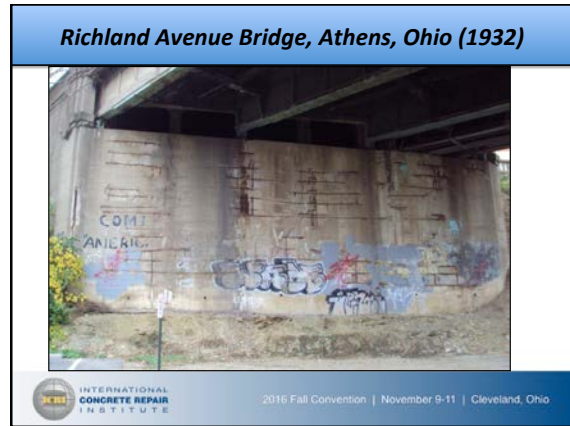
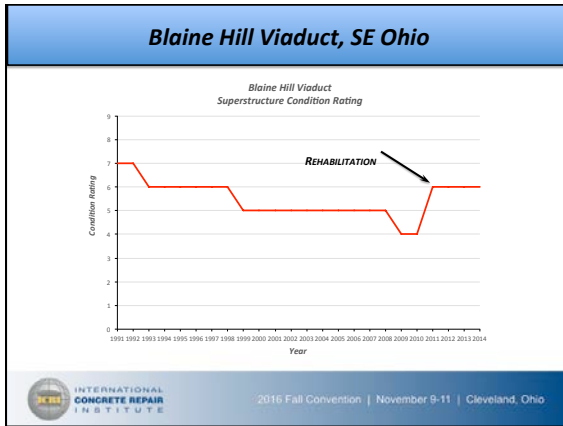
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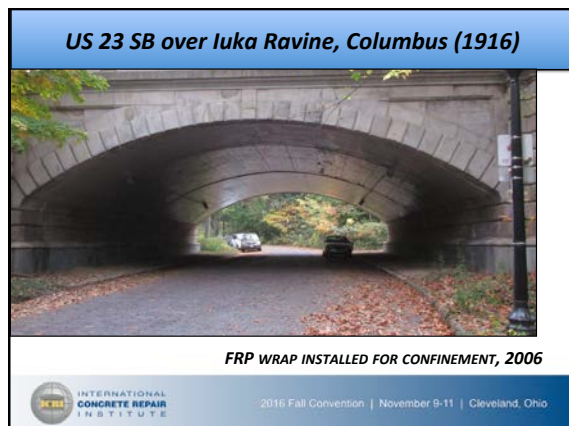
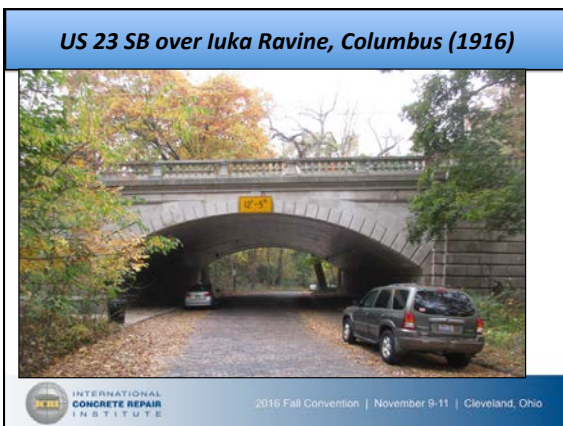
Jefferson Street Bridge, Fairmont, West Virginia Rehabilitated 2001




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US 23 SB over Iuka Ravine, Columbus (1916)



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Jericho Bridge, SE Ohio (1936)

FRP WRAP INSTALLED FOR STRENGTHENING, 2012



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Jericho Bridge, SE Ohio



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Jericho Bridge, SE Ohio



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Jericho Bridge, SE Ohio

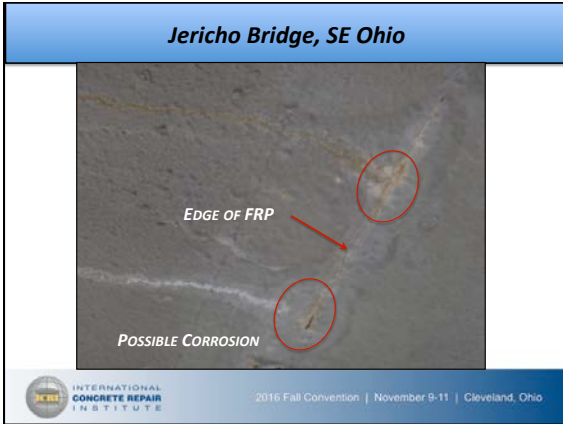


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Jericho Bridge, SE Ohio



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Caution with FRP Wraps for Confinement

LONG-TERM MONITORING OF CARBON FIBER-REINFORCED POLYMER-WRAPPED CONCRETE COLUMNS UNDER SEVERE ENVIRONMENT, ACI STRUCTURAL JOURNAL, NOV.-DEC. 2006.

- ACCELERATED 48-MONTH CHLORIDE ATTACK ON SPECIMENS.

CONCLUSION:
FRP WRAP REDUCE CORROSION TO 10% OF NORMAL ACTIVITY.

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Caution with FRP Wraps for Confinement

Design of Bonded FRP Systems for Repair and Strengthening of Concrete Bridge Elements
 First Edition 2012

1.2—APPLICATION OF FRP
1.2.1—General

In general, procedures for the installation of FRP systems are developed by the manufacturer and can vary between different systems. Two optional types of externally bonded FRP systems are available. The first type consists of dry fiber-fabric sheets saturated with an epoxy resin. This type of system is referred to as the wet-layup technique. The second type of system consists of precured fiber/resin laminates (manufacturer fabricated), which are bonded to the concrete surface with an adhesive resin. The wet-layup system is the more versatile of these systems because the fabric/cloth is flexible and can conform to most shapes in the field. Installation procedures may also vary depending on the type and condition of the structure to be strengthened.

The application of FRP systems will not stop the ongoing corrosion of existing steel reinforcement. The cause of corrosion to internal steel reinforcement should be addressed and corrosion-related deterioration should be repaired prior to application of any FRP system.

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Caution with FRP Wraps for Confinement

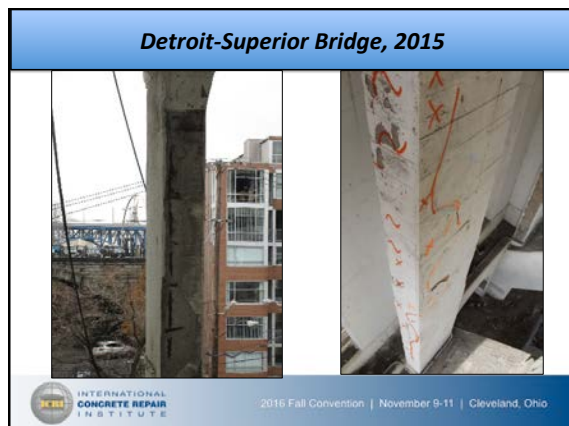
USE OF FRP WRAPS DOES PRESENT A NEED TO EDUCATE BRIDGE OWNERS THAT FRPs MAY HAVE SOME LIMITATIONS TO THE LONG-TERM SERVICE OF THEIR BRIDGES.

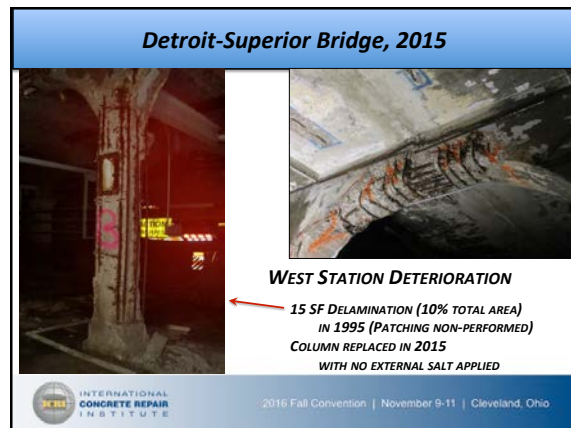
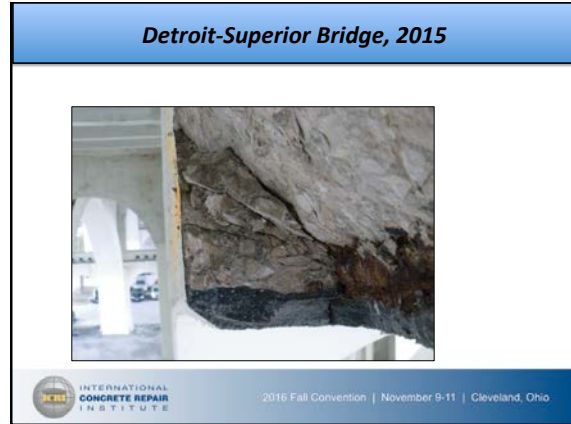
WRAP AND WALK AWAY IS THE NOT THE ANSWER!

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Detroit-Superior Bridge, 2015

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Conclusion

WE NEED TO:

1. **MONITOR THE PERFORMANCE IN-SERVICE CATHODIC PROTECTION APPLICATIONS, AND TELL BRIDGE OWNERS HOW IT IS WORKING.**
2. **CONTINUE TO EDUCATE BRIDGE OWNERS ON VALUE OF CATHODIC PROTECTION AND ITS LONG-TERM VALUE AND NEED TO BE USED WITH FRP CONFINEMENT, BECAUSE OPINIONS AND KNOWLEDGE VARIES.**
3. **CONTINUE TO EDUCATE BRIDGE ENGINEERS ON PROPER METHODS TO EVALUATE CONCRETE, INCLUDING TESTING FOR CARBONATION.**

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- **DAVID JONES, PENNONI**

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