

BUREAU of BRIDGES



and STRUCTURES

Jason DeRuyver, PE

Structure Preservation and Support

Substructures



Michigan Bridge Week 2023



3 Challenges

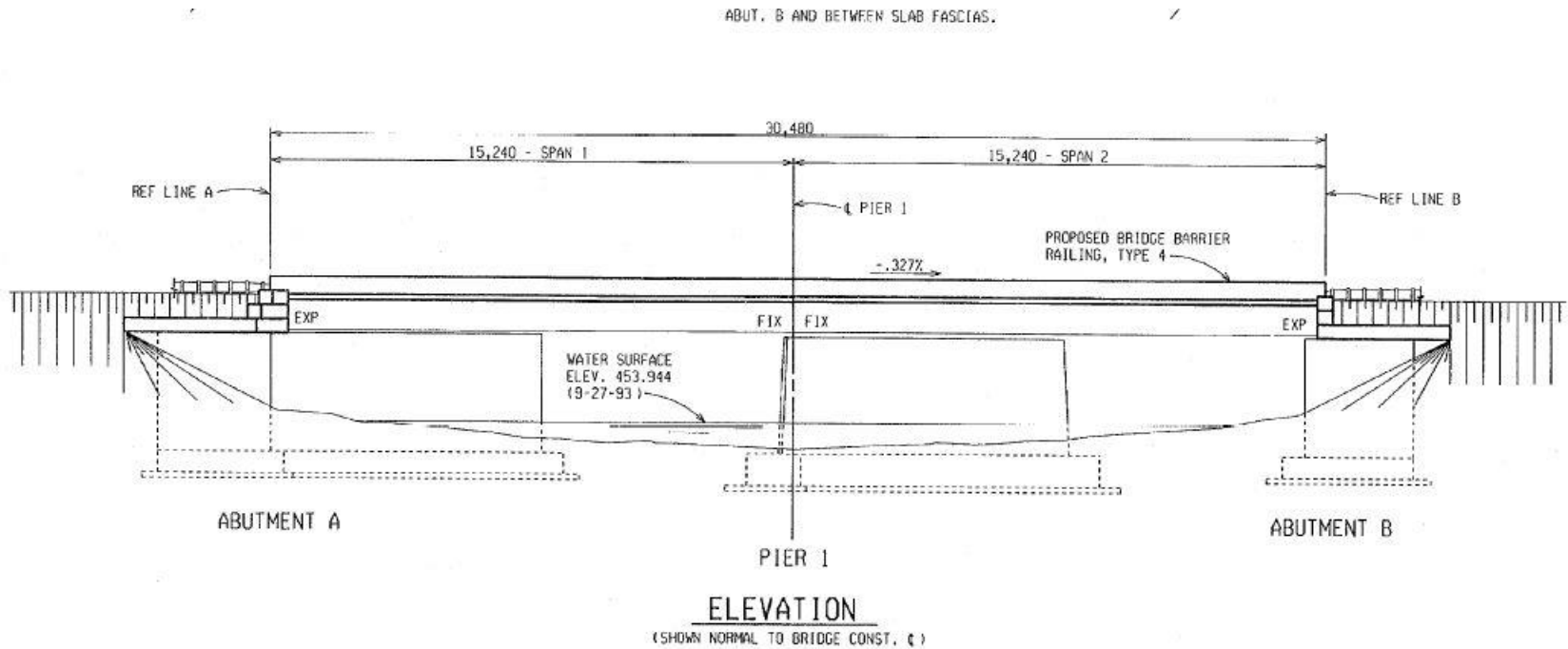
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(517) 242-2988

- Is your bridge going to move the way you expect?
 - Check your details
 - Check your bearings
 - Detail Fascia to Fascia
- Standards are great but.....
 - Does the standard apply?
 - Are additional details going to be required?
 - Will the repair fix what caused the problem?
- Never say again.....
 - Construction will figure it out.
 - That's how we've always done it.

Case 1 – B03-27022 – US-2 over Big Presque Aisle

Jason DeRuyver, P.E.
 (517) 242-2988

- Deck Replacement in 2000
 - Moved Expansion Joint off bridge.
 - Original Bridge Fixed Pier with Expansion Abutments for bearings.



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Case 1 – B03-27022 – US-2 over Big Presque Aisle

- Did the bridge move as expected?

Jason DeRuyver, P.E.
(517) 242-2988

Case 1 – B03-27022 – US-2 over Big Presque Aisle

- Did the bridge move as expected?
 - RFA Submitted 8-19-2015
 - RFA - JN 204336 – Let 1/10/2020
 - \$401,000 – Put expansion joints at reference lines, substructure repairs.



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and STRUCTURES

Jason DeRuyver, P.E.
(517) 242-2988

SCAN TEAM REPORT

NCHRP Project 20-68D, Scan 19-01

Leading Practices for Detailing Bridge Ends and Approach Pavements To Limit Distress and Deterioration

Supported by the

National Cooperative Highway Research Program

The information contained in this report was prepared as part of NCHRP Project 20-68A U.S. Domestic Scan, National Cooperative Highway Research Program.

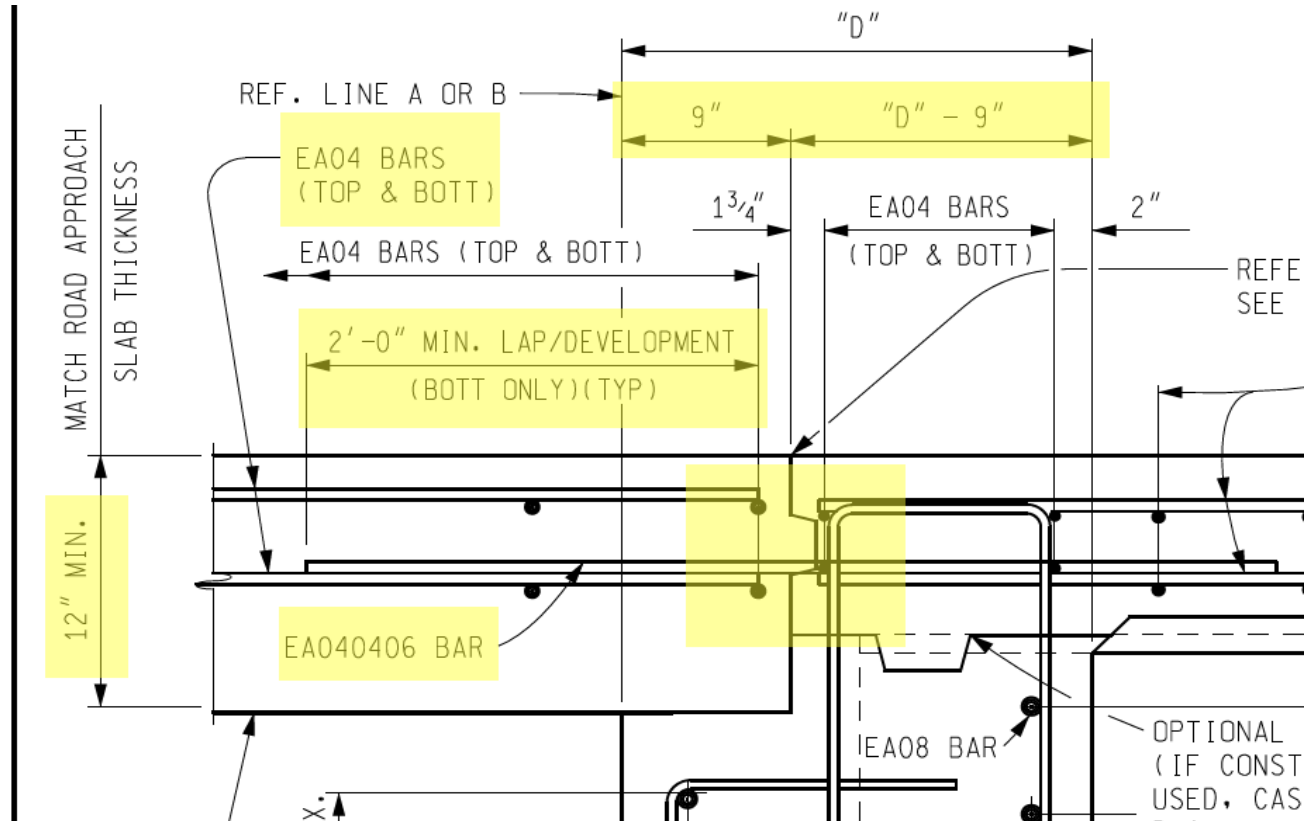
SPECIAL NOTE: This report **IS NOT** an official publication of the National Cooperative Highway Research Program, Transportation Research Board, or the National Academies of Sciences, Engineering, and Medicine.



Domestic Scan Program – MDOT Moving Forward

Jason DeRuyver, P.E.
 (517) 242-2988

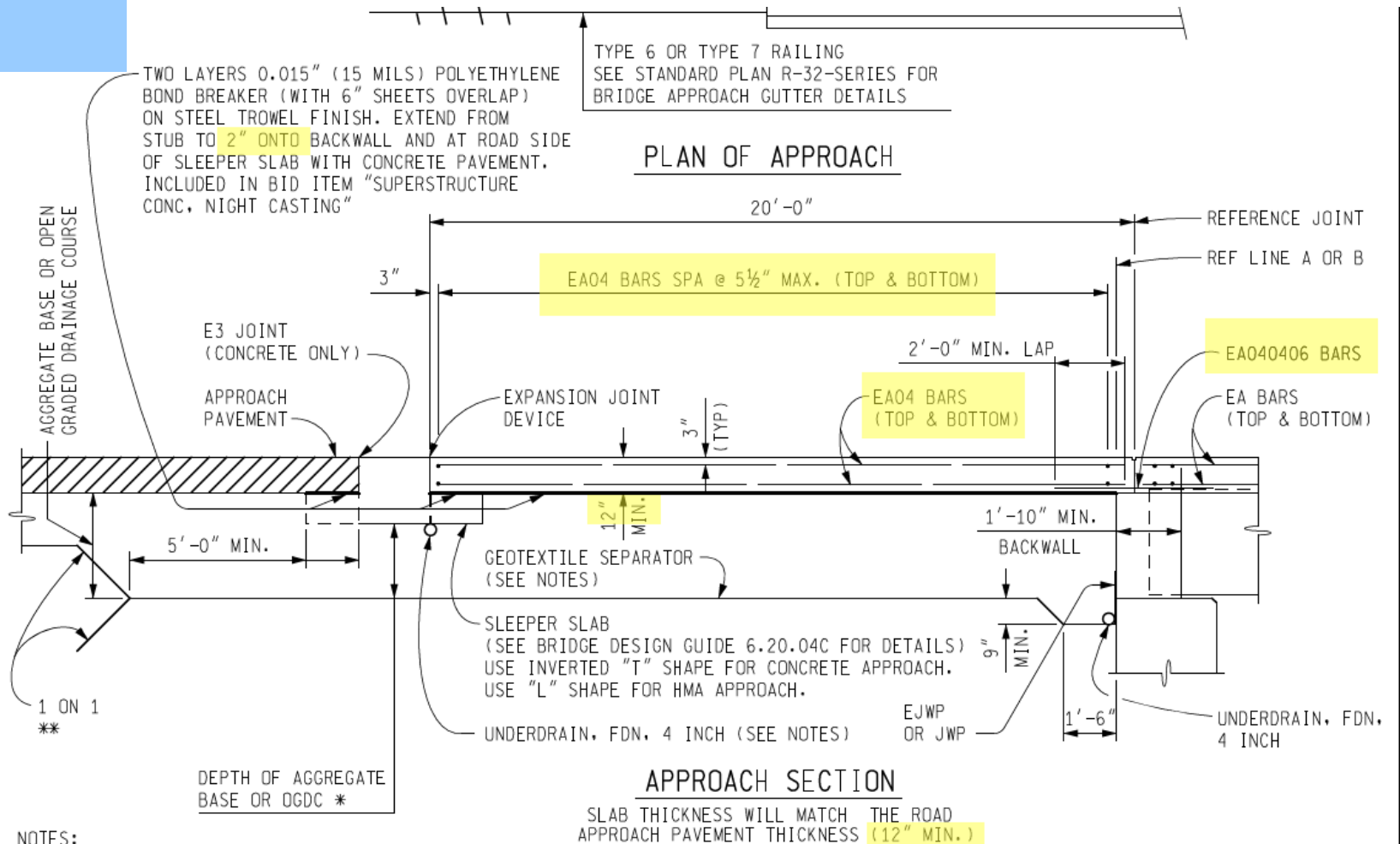
- 2020 – MDOT Created End of Bridge Details Subcommittee





Domestic Scan Program – MDOT Moving Forward

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(517) 242-2988



NOTES:

Case 2 – R01-23152 – I-96WB over GTW RR

- Substructure Patching
 - RFA 8/12/2016

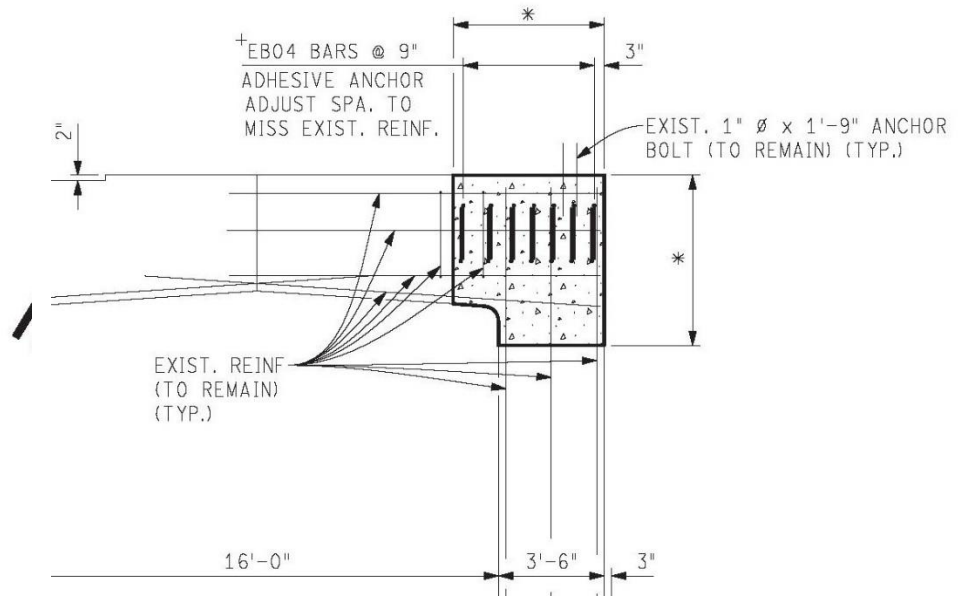
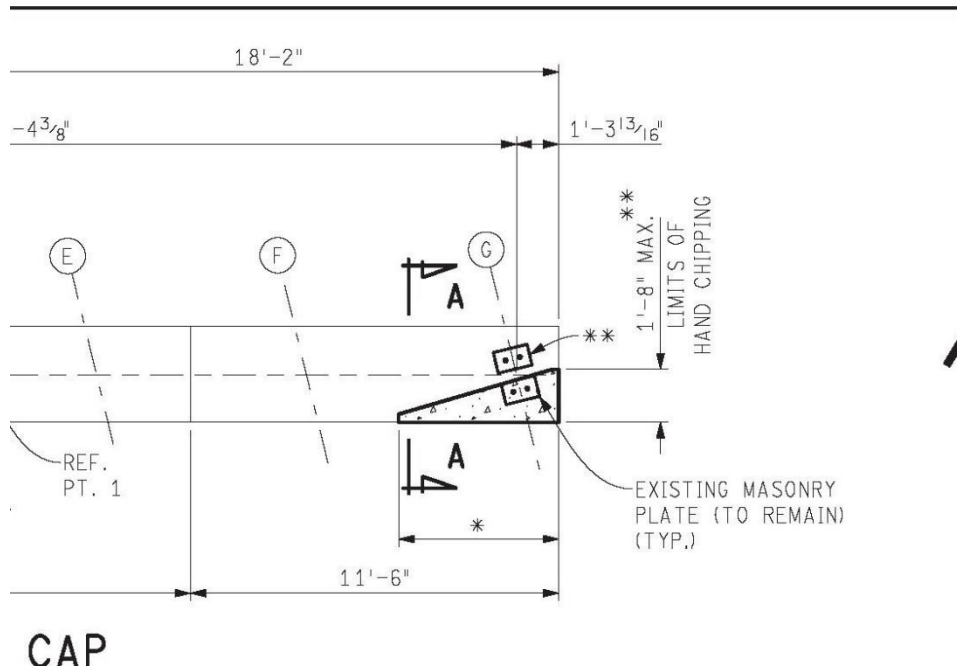
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(517) 242-2988



Case 2 – R01-23152 – I-96WB over GTW RR

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- **Substructure Patching**
 - 200411 – Substructure Patching – 2018
 - Will the standard repair give us the life we expect?

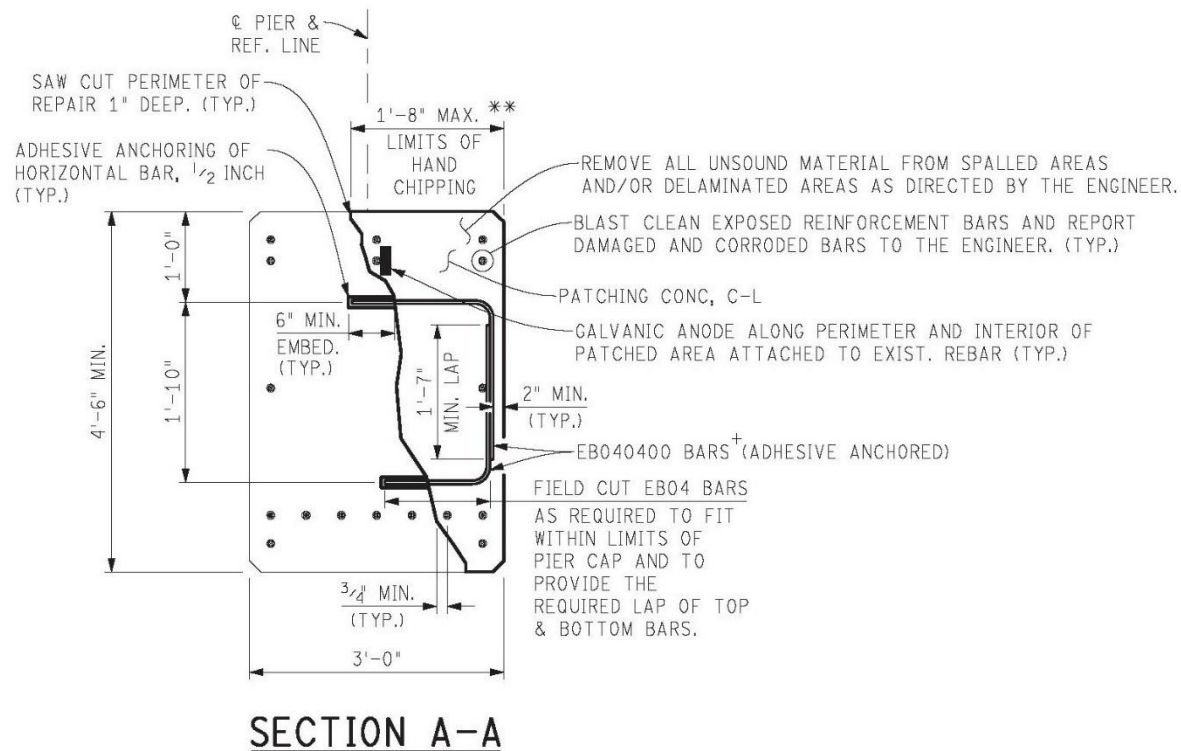


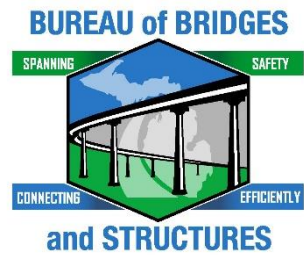


Case 2 – R01-23152 – I-96WB over GTW RR

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(517) 242-2988

- Substructure Patching
 - 200411 – Substructure Patching – 2018
 - Will the standard repair give us the life we expect?





Case 2 – R01-23152 – I-96WB over GTW RR

- **Substructure Patching**
 - Did we chip to sound concrete?

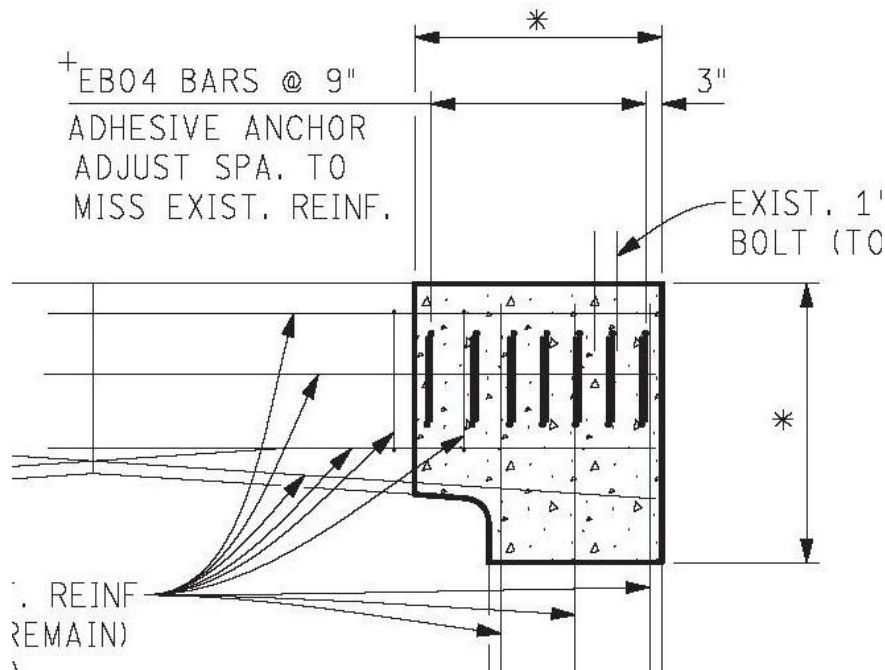
** CONTRACTOR SHALL NOT HAND CHIP PAST THE LIMITS SHOWN AND SHALL TAKE PROPER STEPS TO AVOID UNDERMINING THE SPAN 2 BEAM G MASONRY PLATE AT PIER 2 DURING HAND CHIPPING OPERATIONS. NOTIFY ENGINEER IF UNSOUND CONCRETE IS FOUND BEYOND THE LIMITS SHOWN.

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(517) 242-2988

Case 2 – R01-23152 – I-96WB over GTW RR

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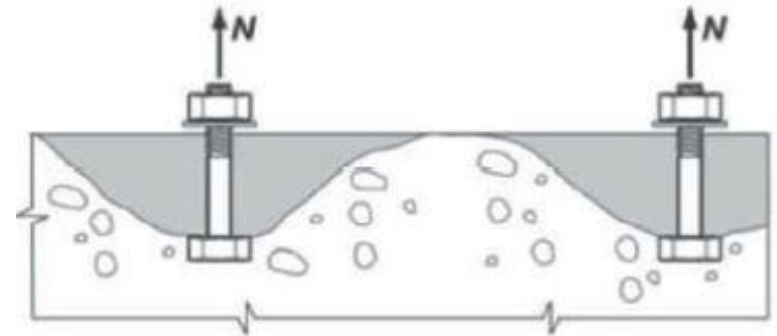
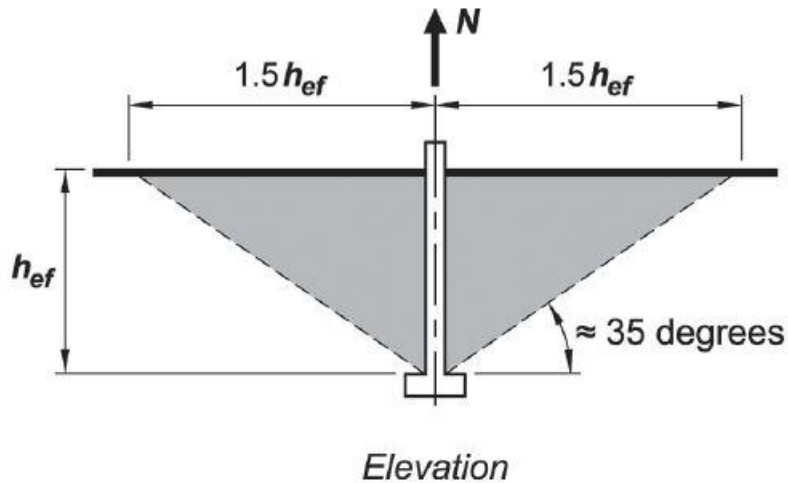
- **Substructure Patching**
 - Was minimum 12d Embedment enough?
 - Were #4 Bars Sufficient to hold new patch to existing concrete?



Case 2 – R01-23152 – I-96WB over GTW RR

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- **Substructure Patching**
 - Was minimum 12d Embedment enough?
 - Edge distance and overlap considerations.



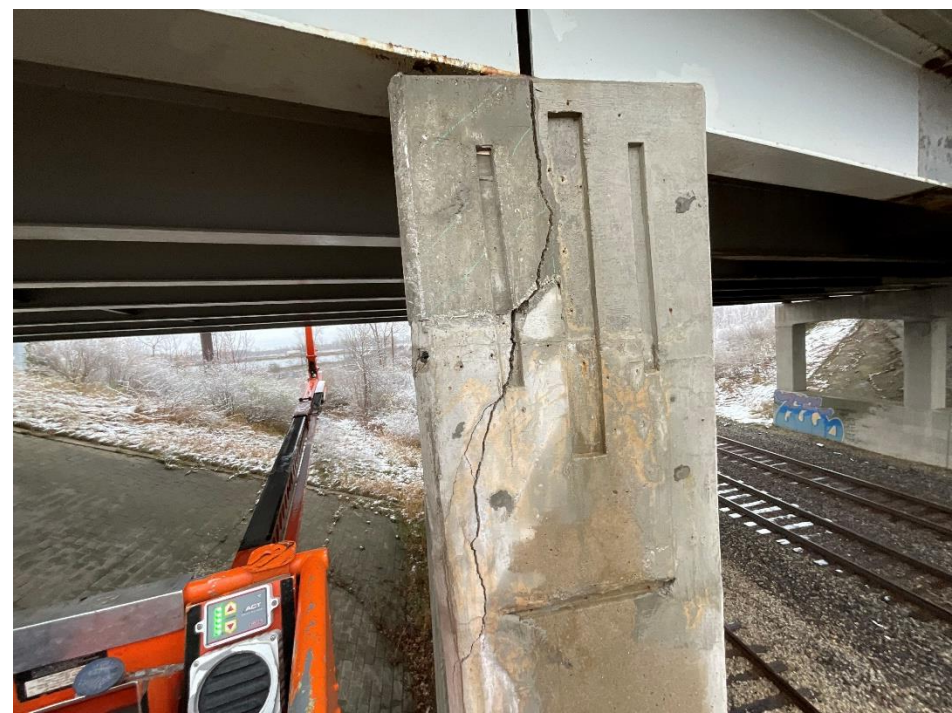
(iii) Concrete breakout

Fig. R17.3.2a—Breakout cone for tension.

Case 2 – R01-23152 – I-96WB over GTW RR

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- Substructure Patching
 - RFA 9/22/2022 – 4 years after construction



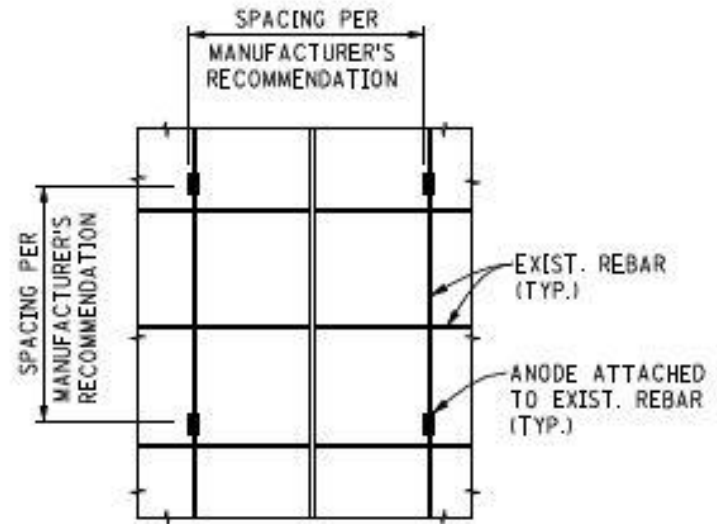
Case 2 – R01-23152 – I-96WB over GTW RR

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 (517) 242-2988

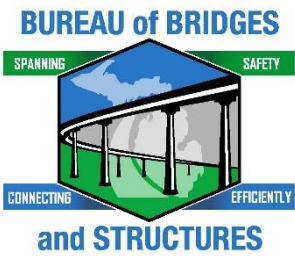
- **Substructure Patching**
 - What about the Anodes?
 - Base Quantity on 24 inch spacing?
 - Call for Contractor to place per Manufacturer?

MISCELL		
ITEM	UNIT	R01 OF 2315
Hand Chipping, Other Than Deck	Cft	25
Patch, Forming	Sft	20
Patching Conc, C-L	Cyd	1
Embedded Galvanic Anode	Ea	10
Slope Paving Header	Ft	25
Slope Protection, Replace	Syd	39

THESE QUANTITIES ARE AS DIRECTED BY THE ENGINEER



GALVANIC ANODE DETAIL

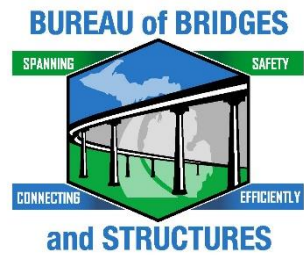


Case 2 – R01-23152 – I-96WB over GTW RR

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(517) 242-2988

- Substructure Patching - Anodes
 - Manufacturers

712.03Y Material Source Guide		
Embedded Galvanic Anodes		Zinc Content (Lb)
MasterProtect CP 8065	BASF	0.14
MasterProtect CP 8105	BASF	0.23
MasterProtect CP 8150	BASF	0.35
Sentinel-GL	Euclid	0.08
Sika FerroGard 650	Sika	0.14
Sika FerroGard 670	Sika	0.23
Sika FerroGard 675	Sika	0.35
Galvashield XPC	Vector	0.088
Galvashield XPT	Vector	0.13
Galvashield XP2	Vector	0.22
Galvashield XP4	Vector	0.35
Galvashield XPX	Vector	0.73

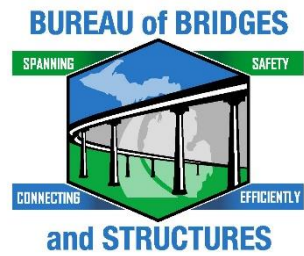


Case 2 – R01-23152 – I-96WB over GTW RR

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(517) 242-2988

- Substructure Patching - Anodes
 - Manufacturers Recommendation
 - High or Low Corrosion Risk? Did
 - Did we tell contractor?

SIKA	650	670	675
Steel Density Ratio - High Corrosion Risk	Spacing (inch)		
0.2	25	27	28
0.21-0.46	22	24	25
0.47-0.7	19	22	24
0.71-0.93	17	20	22
0.94-1.15	15	19	21
1.16-1.36	13	17	19
1.37-1.56	12	16	18
1.57-1.75	11	16	18
1.75-1.93	10	15	17
1.94-2.1	9	14	16



Case 2 – R01-23152 – I-96WB over GTW RR

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- Substructure Patching - Anodes
 - Manufacturers Recommendation
 - What's the steel density ratio?

Surface Area of Steel ÷ Surface Area of Concrete

Surface area of steel = $\pi \times D \times L \times n$

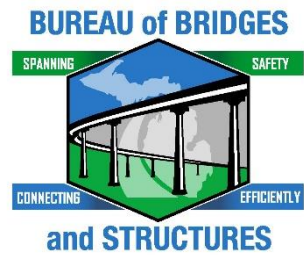
Surface area of concrete = $12'' \times 12'' = 144 \text{ in}^2$

$\pi = 3.14$

D = bar diameter

L = length of bars in calculated area (always 12'' in this calculation)

n = number of bars in calculated area ($12'' \div \text{spacing}$)



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(517) 242-2988

- Substructure Patching - Anodes
 - Manufacturers Recommendation
 - What's the steel density ratio?

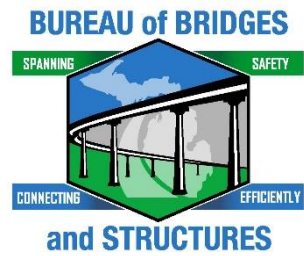
Calculation

Pier Column Vertical: #10 bars at 15 inch O.C.

Pier Cap Horizontal: #9 bars at 18 inch O.C.

Pier Stirrups: #5 bars at 17 inch O.C.

Steel Density = 0.58

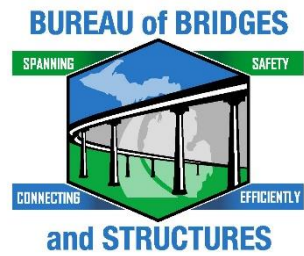


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1.57-1.75	11	16	18
1.75-1.93	10	15	17
1.94-2.1	9	14	16



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- Substructure Patching- Anodes
 - Manufacturers Recommendation

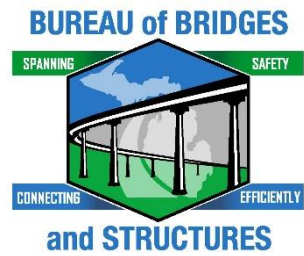
Vector	XPT/XPC	XP2	XP4/XPX
Steel Density Ratio - High Corrosion Risk	Spacing (inch)		
0.3		18	28
0.31-0.6		12	19
0.61-0.9		10	15
0.91-1.2		8	13
1.21-1.5		7	11
1.51-1.8		6	10
1.81-2.1		5	9



Case 2 – R01-23152 – I-96WB over GTW RR

- Substructure Patching - Anodes
 - Installed per Manufacturers Recommendation
 - Could have double the anodes over quantity

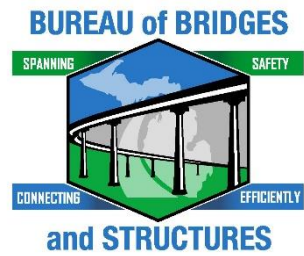
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Case 2 – R01-23152 – I-96WB over GTW RR

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- **Substructure Patching - Anodes**
 - Speaking of “Installed per Manufacturers Recommendation”
 - What does spec book say?
- *Install galvanic anodes to existing uncoated reinforcement along the perimeter of the repair, spaced as shown on the plans and in accordance with the manufacturer’s recommendations.*
- *Do not space anodes more than 24 inches apart. Provide ¾-inch clearance between anodes and substrate to allow repair material to encase anodes*



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- **Substructure Patching - Anodes**
 - Speaking of “Installed per Manufacturers Recommendation”
 - What does spec book say?

Secure galvanic anodes as close as possible to the patch edge using anode tie wires. Tighten tie wires to prevent free movement.

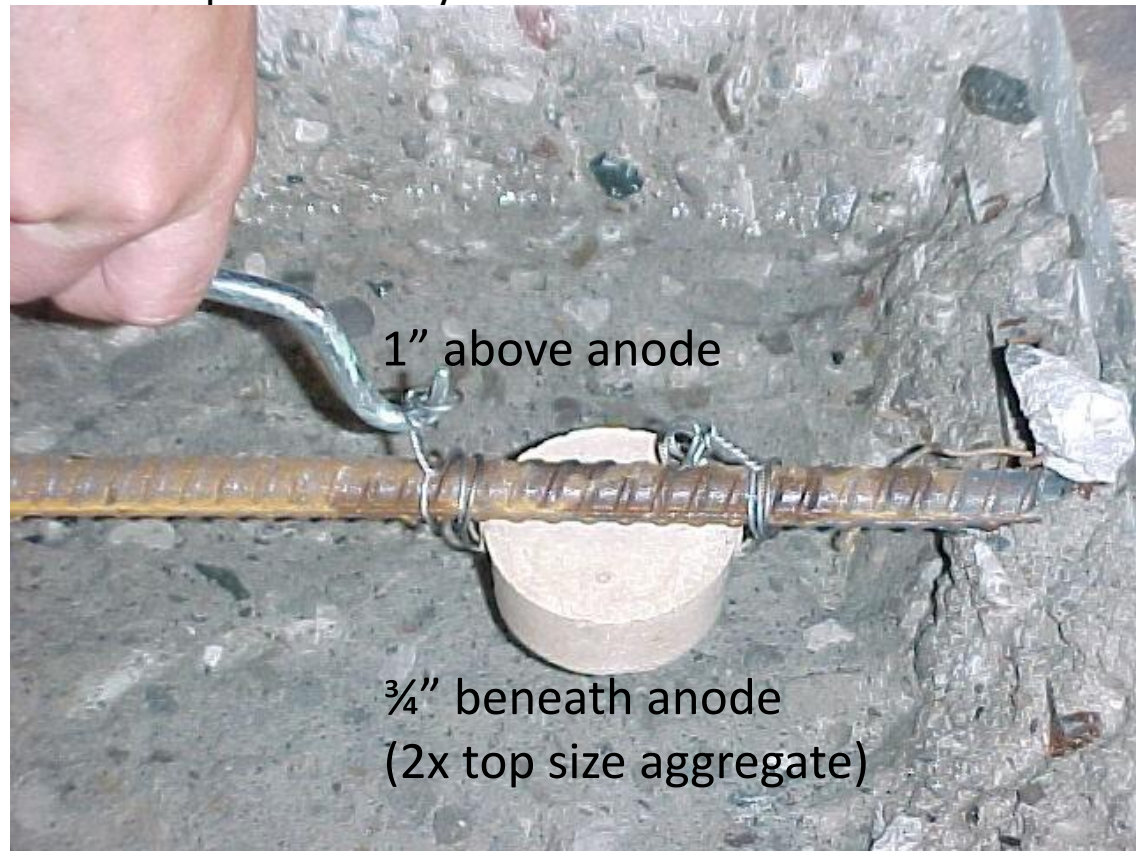
If tying anodes onto a single uncoated steel reinforcing bar or covering with less than 1½ inches of concrete, place anodes under the uncoated reinforcing steel. Secure anodes to uncoated reinforcing steel according to the manufacturer’s recommendations

If 1½ inches of concrete covers the anode, anodes may be placed at the intersection between two uncoated bars and secured to each bar.

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- **Substructure Patching - Anodes**
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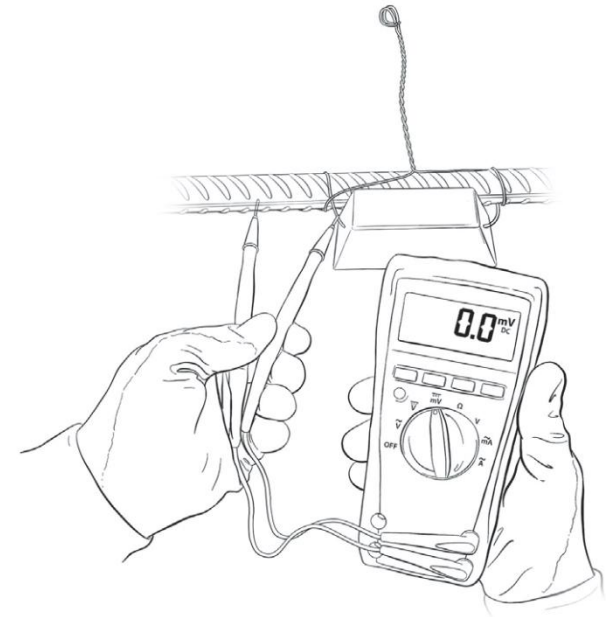


Case 2 – R01-23152 – I-96WB over GTW RR

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- **Substructure Patching - Anodes**
 - Speaking of “Installed per Manufacturers Recommendation”
 - What does spec book say?

Confirm electrical connection between anode tie wires and uncoated reinforcing steel with a multi-meter. Ensure a direct current (DC) resistance of no greater than 1 ohm.

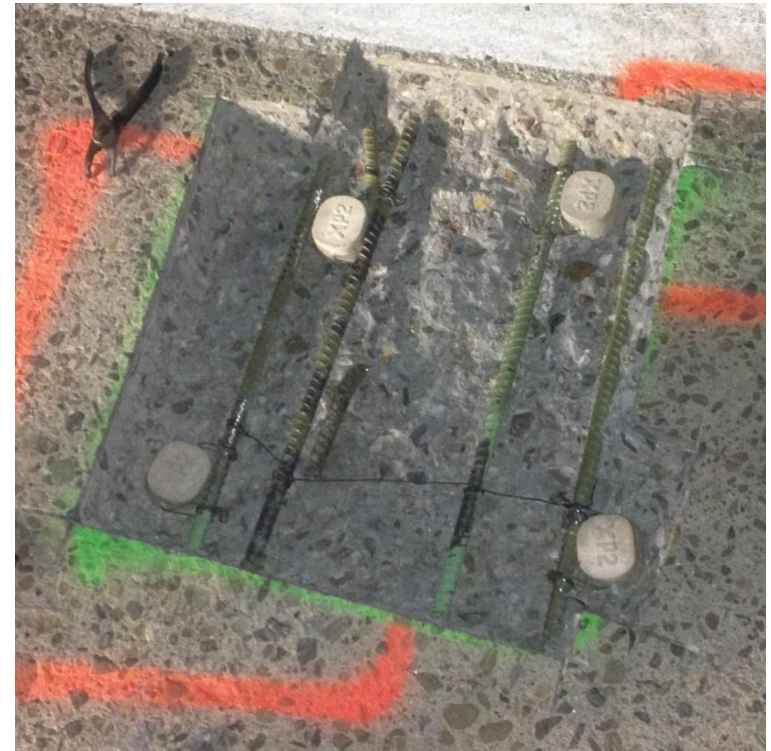


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- Substructure Patching - Anodes
 - Speaking of “Installed per Manufacturers Recommendation”
 - What does spec book say?

Confirm electrical continuity of exposed, uncoated reinforcing steel in the repair area. Steel reinforcement is considered continuous if the DC resistance is not greater than 1 ohm. If the DC resistance is greater than 1 ohm, establish electrical continuity with uncoated steel tie wire





Case Study Conclusions

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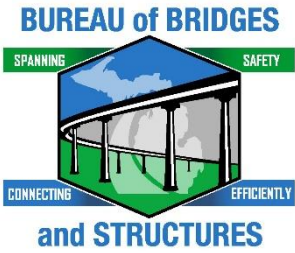
- Design Your Repair Details
 - Minimum Anchor Embedment is not a design. Use ACI 318
 - Ask yourself why the bridge needs repair.
 - Substructure Repair Considerations
 - Do I need a PRJ?
 - Do the bearings need maintenance or replacement?
 - Did a previous project have unintended movement restrictions?



Case Study Conclusions

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(517) 242-2988

- Design Your Repair Details
 - Anodes Spaced at 24 inch or manufacturer recommendation is not a design.
 - Is “Each” the correct anode payment unit?
 - What are you protecting? High or Low Corrosion Potential?
 - How much Zinc is required to protect the steel density ratio of your patch?



Column Repair - SB I-75 Ramp to EB I-69

S-13 of 25042

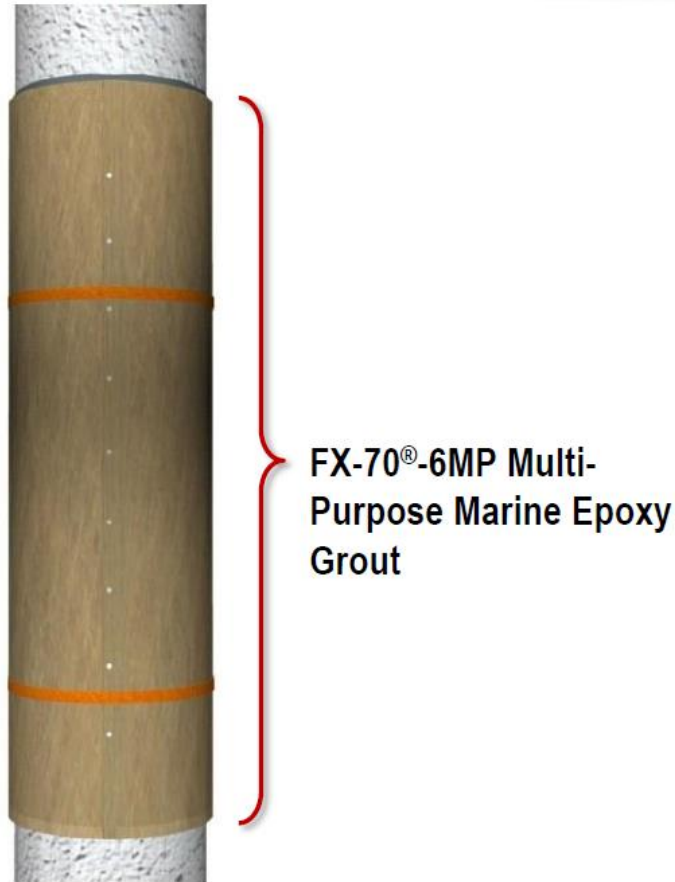
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(517) 242-2988





FX-70 Column Repair

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FX-70®-6MP Multi-Purpose Marine Epoxy Grout

- Simpson Strong-Tie product
- Used when section loss is 25% or less
- Fiberglass Jacket
- Filled with three component, epoxy grout
- $\frac{1}{2}$ " annular void between jacket and column (obtained with spacers)
- Used on Concrete, Steel or Timber Piles

FX-70 Jacket Shapes

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FX-70 Track Record

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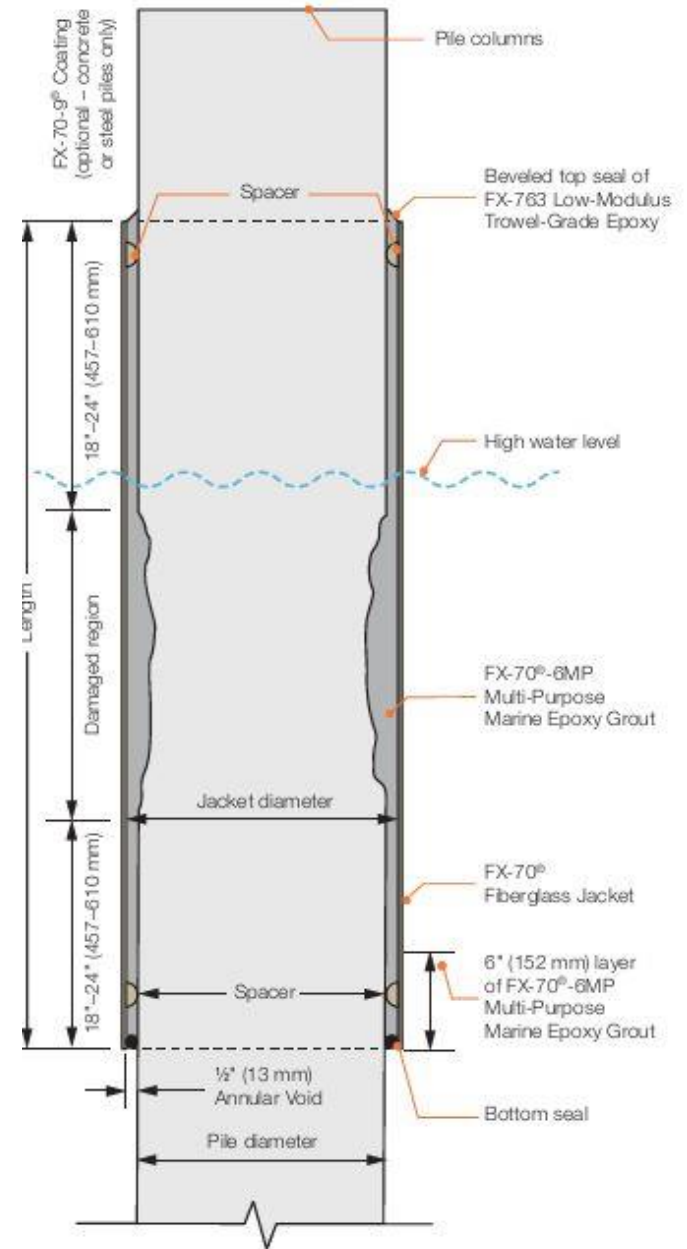
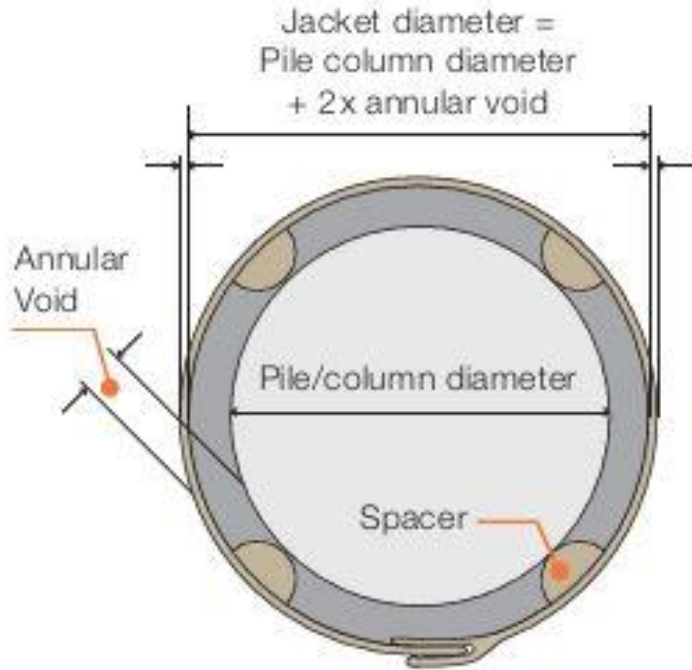
Case Study

- Chesapeake Bay Bridge (US-50)
- 300 jackets installed
- 55' diameter with ½" annular void
- 20+ years in service



SB I-75 Ramp to EB I-69 S-13 of 25042

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(517) 242-2988





FX-70 Column Repair

- Installation
 - In-place repair begins by placing spacers and a bead of FX-763CTG into the locking groove of the jacket.
 - Open the jacket, place it around the pile to be repaired and then close it by inserting the tongue into the locking groove.

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(517) 242-2988





FX-70 Column Repair

- Installation
 - Install a temporary backer-rod bottom seal to contain the initial epoxy grout installation.
 - Temporarily secure the jacket around the pile to keep it correctly positioned during the installation.





FX-70 Column Repair

- Installation
 - To secure the tongue-and-groove joint, install a stainless-steel, self-tapping machine screw every 6 in.
 - Pour or pump at least 6 in FX-70-6MP™ into the jacket to create the permanent bottom seal.

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(517) 242-2988





FX-70 Column Repair

- Installation
 - Once the FX-70-6MP bottom seal has set, fill the remaining space inside the jacket with FX-70-6MP.
 - Create a tapered bevel with FX-763 mixed with FX-701 to eliminate the possibility of water pooling on top and to create a water- and chemical resistant barrier.

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(517) 242-2988



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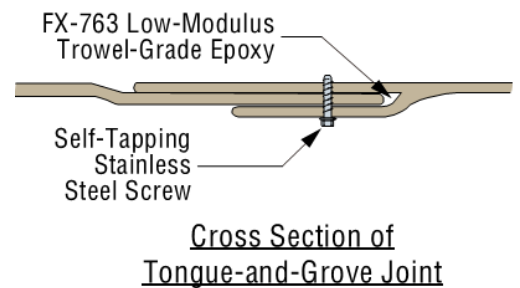
S-13 of 25042

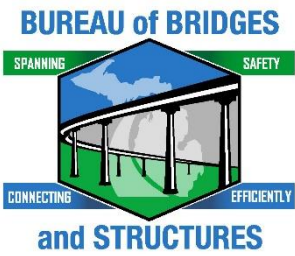
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SB I-75 Ramp to EB I-69 S-13 of 25042

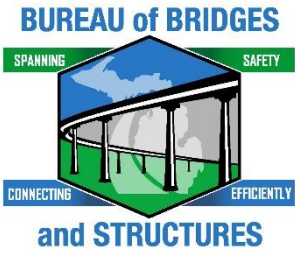
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SB I-75 Ramp to EB I-69 S-13 of 25042

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SB I-75 Ramp to EB I-69

S-13 of 25042

Cost

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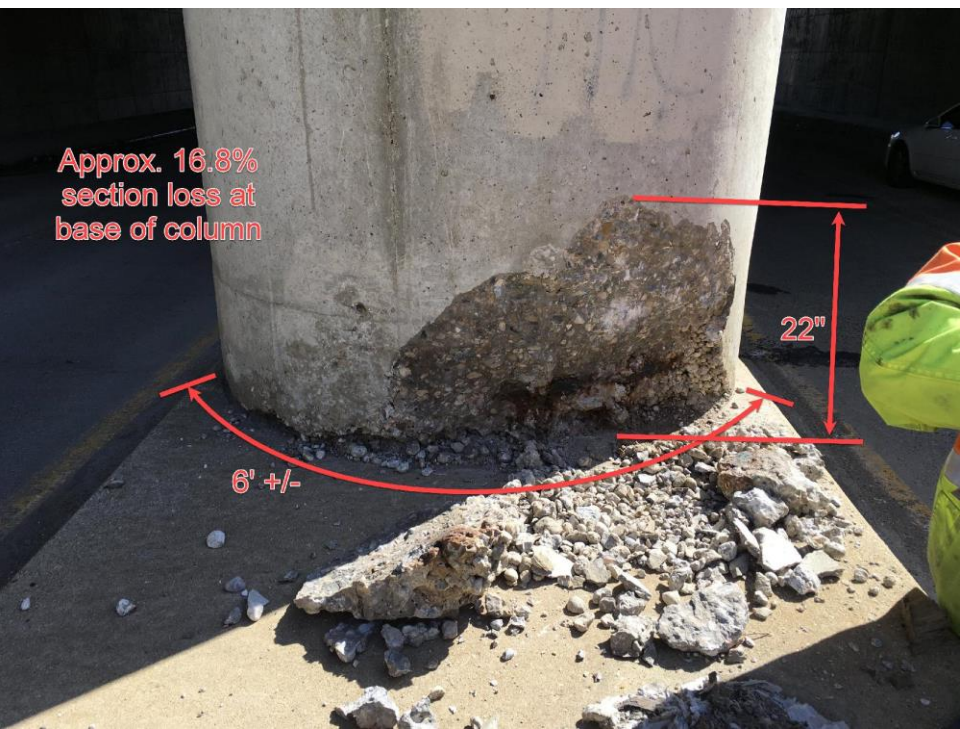
Simpson Strong-Tie FX-70 Fiberglass Jackets

<i>Item Description</i>	<i>Quantity</i>	<i>Cost</i>
FX Round Jacket 37" DIA x 10 Feet	4	\$3075.08
FX 70-6 MP Marine Epoxy Kit (15G + 10 Bags)	3	\$2808.00
763 Trowel Grade Epoxy Paste Cartridge	3	\$114.84
763 Trowel Grade Epoxy Paste (3 gal kit)	1	\$208.35
701 Graded Epoxy Filler 60# Bag	1	\$11.12
Shipping / Handling		\$350.00
Miscellaneous Supplies (backer rod / spacers)		\$200.00
	Total:	\$6767.39

I-475 over CSX RR and Pierson Rd R03-25132

Jason DeRuyver, P.E.
(517) 242-2988

- RFA – 4/3/2018



I-475 over CSX RR and Pierson Rd R03-25132

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- RFA – 4/3/2018



I-475 over CSX RR and Pierson Rd R03-25132

- RFA – 4/3/2018

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(517) 242-2988





I-475 over CSX RR and Pierson Rd R03-25132

- RFA – Complete

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(517) 242-2988



BUREAU of BRIDGES

SPANNING

SAFETY



CONNECTING

EFFICIENTLY

and **STRUCTURES**

QUESTIONS?

Jason DeRuyver, P.E.
(517) 242-2988

