

# A CRITICAL REVIEW OF VTRC-09-R9

## Field Comparison of the Installation and Cost of Placement of Epoxy-Coated and MMFX 2 Steel Deck Reinforcement: Establishing a Baseline for Future Deck Monitoring

David McDonald, Ph.D., P.E.

### INTRODUCTION

In 2009, a report was published by the Virginia Transportation Research Institute (VTRC) regarding installation and costs of epoxy-coated and MMFX 2 reinforcing in a six-lane bridge on State Route 123 over the Occoquan River in the Town of Occoquan in

Bridge plans originally called for the southbound deck to be reinforced with epoxy-coated reinforcing bars (ECR) and for the northbound deck to be reinforced with clad steel reinforcement. When production requirements for clad steel could not be met by the manufacturer, MMFX 2 bars were installed in the northbound deck (on a 1:1 basis with the original design).

The report states: *“The structure was, therefore, a good candidate for the application of corrosion-resistant reinforcing steel (CRR) to attempt to minimize maintenance costs during the 50-year design life of the structure.”*

This paper reviews information presented in the report and finds that many of the statements reached by the authors cannot be substantiated.

### SUMMARY

Northern Virginia[1]. The bridge has two continuously reinforced decks, three lanes each (triple the former number), a 15-ft median, 10-ft shoulders on each side, and a pedestrian walkway adjacent to the southbound shoulder.

In 2009, a report was published by VTRC regarding installation and costs of epoxy-coated and MMFX 2 reinforcing using data from a single bridge in Northern Virginia. A detailed review of this report found that significant and substantial information was either ignored or disregarded by the researchers. Such information is outlined below:

- Deck cracking was observed in both decks; however, only repairs were undertaken on the ECR deck. These repairs were conducted almost 1 year after being observed and required re-routing of traffic. Costs associated with these repairs were all allocated to the cost of the ECR. It is stated that crack repairs on decks by VDOT are routine; which raises questions regarding why repairs on this structure were left until after the deck had been placed into service?
- Comparison of cost data from the two spans is complicated by weather conditions during the

construction; the ECR deck was placed in winter, whereas the MMFX 2 deck was placed in summer. Such information is not discussed; however, it is likely that such information may help explain deck cracking and minor placement cost differences between the two products.

- The report presents a belief that installation productivity rates for MMFX 2 will improve over time; however, this is unlikely to be the case as workers are already highly familiar with use of similar products. No indication of how this improvement is to be achieved is outlined in the report.
- The authors take unusual lengths to describe that the ECR cost \$5000 more to place than the MMFX 2, even though total material costs for ECR were almost \$100,000 less than the MMFX 2.
- The author's present information stating that construction with "ECR is difficult"; however, this statement ignores the some 65,000 bridges built in the US using this material and that this material remains the material of choice for corrosion resistant reinforcement.
- Comments regarding repair, abrasion and damage to the ECR are made, and the authors provide no supporting evidence.
- Galvanized bars were used in the project; however the authors do not discuss their influence or effect.

- Large portions of the report are based upon speculative values relating to user delays; which were based upon a delay in deciding to seal the bridge after construction.

Based upon detailed review, conclusions presented within this report should not be relied upon for accuracy regarding the performance or cost of ECR and MMFX 2.

### **DETAILED REVIEW**

The work was conducted as it was believed that the project presented an opportunity to evaluate:

- (1) *Cost differential between ECR and MMFX 2*
- (2) *Whether ECR or MMFX 2 could be shown to have an advantage in terms of average labor productivity as measured by ironworker hours required per pound of reinforcement placed.*

The major focus on the report relates to cracks observed in the decks of both the north and southbound decks and the treatment of these cracks; however, observations and conclusions regarding epoxy-coated bars and MMFX 2 were presented.

It is stated:

*The concrete in the southbound (ECR) lanes exhibited cracking soon after the concrete was placed in late 2005. In November 2006, these lanes were sand blasted, sealed with an epoxy coating, and restriped over the course of two weekends. VDOT typically*

*seals cracks in decks to prevent chlorides and moisture from reaching the reinforcement and causing it to corrode. The epoxy coating on ECR does not provide long-term corrosion protection (Weyers et al., 2006). Similar cracking of the concrete in the northbound (MMFX 2) lanes was untreated because corrosion resistant reinforcement such as MMFX 2 can arguably provide long-term corrosion protection (Weyers et al., 2006).*

Several items should be noted regarding this paragraph:

- (1) Cracking was observed soon after placement
- (2) Repair was not conducted until almost one year after the cracks were observed and the bridge was opened
- (3) Repair of cracks is typical
- (4) It was decided that MMFX 2 does not require crack sealing

Several questions are raised by these statements that are not discussed by the authors. These include:

- (1) Why was repair delayed for almost 1 year until after the structure was opened if crack repair is standard VDOT procedure?
- (2) What was the decision process for not repairing the cracks using MMFX 2?

Within the report, the researchers compiled and compared direct and indirect dollar costs reported in inspectors' construction records for the two materials. This included Inspectors' daily work records (DWRs) contain these cost data and also provide accounts of construction activities, crews, and work items. The DWRs were cross-referenced with other reports

internally generated by VDOT (VDOT, Scheduling and Contracting Division, unpublished data, 2008).

The reported Direct and Indirect Costs are shown in Table 1.

The report indicates that the contract bid prices for ECR and MMFX 2 per pound were \$0.51 and \$0.78, respectively. Due to the significant amount of chromium in the MMFX 2, the price of this product is expected to be largely influenced by the price of this material. Second, the patented product, MMFX 2, is only supplied by one manufacturer, whereas ECR is available from multiple sources. In addition, ECR is generally manufactured using recycled steel obtained locally near the steel mills whereas MMFX 2 is made in a single location using approximately 10 percent of expensive, imported mined minerals.

Regarding the costs for the sealing, it is stated:

*The preponderance of assumptions necessary to choose values for traffic parameters that would be realistic in the middle of the bridge construction period may throw the estimates into a speculative light.*

Thus, it should be re-emphasized that conclusions regarding traffic and usage costs should be considered as speculative.

The report states:

*“The results indicate that compared with ECR, almost 11% more MMFX 2 was placed per total labor-hour. This might be*

September 9, 2009

*due to the less restrictive handling requirements of MMFX 2 relative to ECR, as Figure 34 suggests.”*

The conclusion presented in the report was made without consideration of job scheduling, training or weather conditions. It should also be indicated that the difference in labor amounted to less than \$5000 for the 300 ton or approximately \$500,000 of material used in each bridge. Handling plus material costs for ECR were \$0.61/lb compared with \$0.86/lb for MMFX.

Figure 11 and 17 provide data on construction dates and temperatures. These tables are summarized in Table 2. The concrete placement dates for the ECR were December and January, whereas the placement dates for the MMFX 2 deck was largely constructed in June. Temperatures at placement for the ECR decks were generally less than 55F, whereas temperatures for the MMFX 2 decks were greater than 60F. Figure 23 also shows that snow was present during the ECR pour dates.

It is well known that winter construction is more difficult and more costly than summer construction. In addition, such low temperatures during placement may well have caused the early age deck cracking observed in the ECR decks. The sequence of pours was also different for the ECR and MMFX 2 decks, which may also affect the amount of observed cracking.

The report states:

*“Labor productivity in placing MMFX 2 will probably improve further as familiarity with the material increases.” And  
“It is likely, therefore, that labor productivity could improve further over what was found in this study as MMFX 2 is put into wider use.”*

It is unclear as to what familiarity is required, as one of the marketing aspects of MMFX 2 steel is that it handles exactly the same as black reinforcing bar, which is constantly used by ironworkers.

The researchers provide information on their uncertainty in reaching conclusions as stated in their report.

*“The special handling requirements for ECR are a plausible explanation for the lower average labor productivity in the placement of ECR compared to that for MMFX 2, although the extent is indeterminable from inspectors’ records.”*

No acknowledgement was provided regarding weather conditions during time of placement, which significantly affects bar placement.

It is stated:

*“The practical demands of construction make some of the requirements for ECR difficult to satisfy. By contrast, MMFX 2 does not require the specialized handling and transport that the CRSI recommends for ECR.”*

ECR is routinely used throughout the world and handling issues are well addressed by the industry. Such comments clearly indicate an uninformed view about construction practices.

The report comments on “*possible sources for the coating damage that existed during construction,*” and these are described in the report as follows:

*In Figure 12(a), ECR had been cut and required repair of the end before the concrete could be placed.*

Cutting of bars in the field only occurs when errors in specification or construction occur. Most bars arrive onto a jobsite in ready-to-place condition with bar ends already repaired. Despite this, patching of cut ends is generally not a large factor and should only account for one or two hours of work on any project.

*In Figure 12(b), grit from the bottom of shoes could have abraded the coating.*

Grit on the bottom of workers shoes does not cause abrasion of the coating. Section A1.3.7 of ASTM A775 describes abrasion testing of epoxy-coatings used for reinforcing bars to ensure coatings are not damaged during typical use.

*In Figure 12(c), the impact from the concrete aggregate as it left the hose and contacted the ECR mat could have abraded the coating.*

No evidence is provided in this report that the means and methods used to place the concrete actually caused damage to the coatings.

Figure 16 of the report shows photos of galvanized bars in the parapet on Span A; however, this product is not discussed at all within the report.

It is stated that:

*“The surface of the steel (MMFX 2) exhibited some surface rusting, but according to ASTM A1035 this was acceptable as long as the “mass, dimensions, cross-sectional area, and tensile properties of a test specimen” met the requirements described in the specification (ASTM International, 2004).”*

ASTM A1035 describes a high strength reinforcing bar and not a corrosion-resistant bar and thus reference to handling regarding corrosion performance is not included. Work by Scully[2], also conducted at the VTRC, states; “the presence of mill scale on any of the corrosion-resistant materials reduced the chloride threshold to approximately that of carbon steel. Therefore, pickling is highly recommended in any reinforcement substitute.”

## CONCLUSIONS

Based upon review of the report many of the conclusions reached by the authors cannot be substantiated. Review has shown that:

- Material costs for ECR are cheaper than for MMFX2
- Handling costs are similar for both systems
- If cracks in decks are to be repaired, they should be done prior to bridge opening to prevent user delays

**Table 1: Reported Direct and Indirect Costs**

Costs	ECR	MMFX 2	Per lb	Per lb
Amount of Steel (lb)	572,121	674,447		
Cost of reinforcing	\$293,040	\$526,189	\$0.51	\$0.78
Cost of labor to handle, transport and install the reinforcing steel	\$54,101	\$59,062	\$0.095	\$0.088
Cost of seal operation payable to the prime contractor (ECR only)	\$170,455	-	\$0.30	-
Road user costs during sealing	\$820,000 to 1,140,000	-	-	-
VDOT inspector	\$2800	-	-	-
Police	\$300 - \$1000	-	-	-

**Table 2: Construction dates and temperatures.**

Span	ECR			MMFX 2		
	Date	Temp Max (F)	Temp Min (F)	Date	Temp Max (F)	Temp Min (F)
A	10/6/05	77	49	10/20/06	70	49
B	10/27/05	52	35	11/2/06	-	-
C	12/8/05	38	23	6/1/07	-	-
D	12/30/05	47	34	6/14/07	62	62
E	1/6/06	43	25	6/12/07	85	68
F	1/12/06	60	39	6/18/07	96	72
G	12/21/05	39	24	5/30/07	-	-
Crack repair	11/30/06 to 11/12/06					

---

**REFERENCES**

1. Sharp, S.R. and A.K. Moruza, *Field Comparison of the Installation and Cost of Placement of Epoxy-Coated and MMFX 2 Steel Deck Reinforcement: Establishing a Baseline for Future Deck Monitoring*. 2009, Virginia Transportation Research Council: Charlottesville, VA. p. 82.
2. Scully, J.R. and M.F. Hurley, *Investigation of the Corrosion Propagation Characteristics of New Metallic Reinforcing Bars*. 2007, Virginia Department of Transportation: Richmond, VA 23219. p. 61.