

**June 2019 ABC-UTC Webinar Featured Presentation: Michigan DOT's Use of Externally-Bonded FRP Systems for Bridge Element Strengthening**

#	Questions	Responses
1	Will there be any handout/materials for the presentation? Is it possible to get a copy of the materials/references?	Yes, all handouts are posted to the FIU ABC website.
2	Does the Michigan DOT have a special provision for these FRP systems available to the design community through their website?	Not currently.
<b>Design</b>		
3	What service life do you expect to get out of the FRP?	35-40 years.
4	How is the FRP protected from fire?	In general, it is coated with elastomeric, or epoxy coating. From our research, we found that while the epoxy/resin system will burn away, the fibers remain intact.
5	Are there any concerns about vandalism?	Yes, that's always a concern; however, we do not have any active mitigation measures to address this.
6	Please comment on the effect of UV radiation (sun sensitivity) on the long-term performance of the FRP.	It is a concern; however, we coat the FRP system with elastomeric, or epoxy coatings. In addition, the resin layers also contain UV protection.
7	How are permeability and freeze-thaw cycles of moisture within the concrete members addressed?	The bonded FRP system actually creates a waterproof barrier in the area of the application.
8	What are the codes used for FRP design? Where are they approved? Do they work for earthquake design, including columns?	ACI 440-2R-08 was used. Our specification required the use of materials with material properties that meet Caltrans' specifications for seismic design.
9	Have you used FRP strips instead of wraps for structural strengthening?	No, we have not used the near-surface-mounted strips, or bars.

10	Is it common practice to use galvanic anodes in FRP repair? Was this determined from past poor performance without galvanic anodes?	We use galvanic anodes for patching repairs regardless if FRP systems are used as part of the repair. MDOT uses these galvanic anodes on a lot of patching projects.
11	Were downspouts extended to help prevent potential future concrete column deterioration?	Yes, they were extended down to splash blocks as part of the project, after the FRP systems were installed.
12	What are some of the factors to look for on a good FRP repair project?	Appropriate application of saturants, and rolling the fiber mats to ensure all air voids are removed.
<b>Construction</b>		
13	Please address surface preparation requirements.	From the photos, the corners were rounded for the square columns, and the interface of the patches were ground smooth.
14	Please comment on bonding agents and adhesives of FRP to the substrate.	The material requirements are shown in the specification.
15	Please comment on the availability of trained contractors.	There are many regional contractors that specialize in this work.
16	Did you need to limit live load on the bridge(s) when applying this FRP?	No. The I-75/M-8 pier was supported for the concrete patching repairs only. These are confinement and passive reinforcement applications.
17	Did you perform chloride tests for the columns, and is there is a threshold for the chloride content?	No tests were performed, although active corrosion was found on the reinforcement.
18	How do you feel about the reliability of the application of the FRP, especially when using for strengthening?	We have had good results thus far.
<b>Maintenance</b>		
19	Do you have any past experience with strengthening of concrete members that experience cracking under service load?	Yes, we have applied various techniques for strengthening, such as external post-tensioning, bonded FRP systems, attaching steel members, etc.
20	Please comment on the long-term performance of FRP strengthened members.	We've had good results thus far, and have an application 20 years old with no debonding or other degradation issues.

21	Have you seen debonding failure of the FRP in flexural applications?	Thus far, no. Most of our flexural strengthening applications are relatively new - no more than 10 years old.
22	Please comment on durability and future inspection of the material encapsulated.	So far, the FRP systems are as durable as the concrete they are applied to. Inspection reports note the presence and condition of the FRP systems.
23	Do you have an evaluation plan to monitor the application?	Nothing outside of the normal NBI bridge inspection process.
24	How does the FRP modification change inspection methods or the ability to inspect existing concrete elements?	We have agency-specific elements for bridges with FRP systems, and the condition is noted on the inspection reports.
25	How is it performing over time? What maintenance or special inspection procedures have you implemented?	So far they are performing well. No additional maintenance has been performed on the existing installations.
26	Are there specific notes required in the biennial bridge inspection reports for FRP?	Yes, they are noted on the inspection reports.
27	What provisions are made with the wrap for future visual inspections?	Nothing overly special; we just note the visual appearance, and if there is any debonding, or other deterioration.
<b>Cost</b>		
28	Please comment on cost.	See presentation for cost information.
<b>Questions during Webinar</b>		
29	How long do you need to keep the FRP wrapper around the concrete columns until it is cured?	There are no temporary wrappers used. The FRP wrap is applied, and saturant is rolled in.
30	Did they remove the rust from exposed rebars before patching the piers?	Yes, we have a requirement in our standard specifications requiring sand blasting of corroded reinforcement.
31	Were there restrictions on the concrete removed versus the gross/net area of the concrete column? Or, number of vertical bars exposed?	No, we typically remove one inch behind the existing rebar for mechanical bond, and we limit the area of removal based on the delaminated areas.

32	The column is rectangular. Did you try to round the edges?	Yes, that was required.
33	Why did the heights of the wraps vary from column to column?	We only applied them to the delaminated areas of the columns.
34	What type concrete was used for patching?	Typically we use a latex-modified concrete for patching.
35	What is the curing time of the FRP?	It varies based on the system that is used. For the I-75/M-8 project, the repairs were performed in one day.
36	Can you elaborate on choosing ACI instead of AASHTO for design? I'll be concerned about mixing these two codes.	No mixing of the codes was done. We chose ACI due to the ability to use a little higher strain in the FRP, and the use of more well-established material resistance factors.
37	Can you use the FRP on concrete girders?	Yes, on both reinforced and prestressed concrete girders.
38	How do you address below grade concrete (to foundation)?	We did not excavate down to the foundation, and only focused on deterioration based on visual inspection of elements.
39	It seems that you maintained the flare in the column faces. How did this affect FRP placement and workmanship?	The I-75 Rouge columns were square. The I-75/M-8 column has a slight taper; however, this did not result in difficulties in applying the FRP system.
40	For M-8 Ramp, you mentioned removing load from column before wrapping. How was the unloading done?	We used temporary column supports with timber mat foundations under each beam.
41	Is the \$2470 cost based on the unit cost per SF or SY?	That was the total cost of the materials - fiber and resin.
42	Was vibration due to freeway traffic an issue, and was it considered in designing the FRP strengthening solution, especially the bonding?	No, vibrations were not an issue.
43	In the second example, the column was unloaded prior to patching. When is that necessary?	It was unloaded so we could chip to good concrete around the bearing, which required to go slightly underneath the bearing. The column was unloaded for that reason, not for the FRP wrap.

44	Has MDOT been on the lookout for more opportunities to implement FRP repairs? They seem to be a relatively efficient cost versus structural capacity.	Yes, we use it as often as possible as a tool in the toolbox for asset management.
45	On the Rouge River bridge, was it the actual increase in structural capacity of the columns that made repair/rehab an optimal solution, or is the FRP technology in that application more about insurance - ensuring longevity / durability of the repairs?	The added structural capacity was a minor consideration. We were more concerned with confining the patched concrete to ensure the patch and the original concrete function together.
46	Can the FRP be used to improve seismic resistance in pier columns? Caltrans experience?	I believe so; however, MDOT does not have experience in this regard. This is definitely a Caltrans question.
47	Were there locations with limited access where the FRP was not able to be utilized?	Not on these two projects.
48	Is corrosion of the rebar in the FRP-encased concrete still a concern, considering that you are not wrapping the entire column (or the cap where the water leaks)? How do you know if you have an issue when you cannot see the issues associated with corroding rebar?	No; the corrosion product was sand-blasted off, and galvanic anodes were placed. The FRP system also creates a watertight barrier when properly bonded.
49	Is the FRP a proprietary material? Is it available from at least a few manufacturers?	No, it is not proprietary. Our special provision for the materials is a generic specification.
50	Is that inspection procedure in your Bridge Inspection Manual?	We currently cover identification of all elements. We have specific procedures for FRP elements.