GFRP Deck Project

Construction Report

Bridge #089-022

SR 1627 – New Salem Rd, Union County

Prepared For: North Carolina Department of Transportation

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Executive Summary

The 20th century brought about many innovative changes to the world of construction. While concrete and steel tend to be the materials of choice, technology has introduced a material, which may become the material of choice for future designs. This material is Fiber Reinforced Polymer (FRP). Composites being both light and strong, are being introduced to many applications, including bridge construction.

In an effort to speed construction and increase service life of a bridge, the North Carolina Department of Transportation (NCDOT) looked to composites. A deteriorating bridge in Union County presented the opportunity to test this new concept in bridge construction. Bridge #89-022 over Mill Creek on New Salem Road (SR1627) needed to be removed and rebuilt, so it was chosen to receive the first composite deck in the State of North Carolina. Martin Marietta Composites division, producer of the FRP DuraSpan™ system, was contracted to produce the panels required for the bridge replacement.

The construction of this bridge was funded in large part through a discretionary grant from the FHWA through the Innovative Bridge Research and Construction Program. Evaluation of this structure continues as a part of the NCDOT Research Project 2002-12 entitled "Evaluation of Bridge Analysis vis-à-vis Performance". The results of this evaluation will therefore be contained in the final report for this research to be concluded in the summer of 2003.

First, the existing structure was removed, and the new steel girders were installed. Then, angles were welded to the girders to support the panel and to provide room for grout injection. After the angles were welded in place, the panels were placed in accordance with the Martin Marietta Installation Guide by NCDOT personnel, and under the supervision of Martin Marietta representatives. After the deck panels were placed, a combination of shear studs and grout were used to permanently attach the panels to the girders. Once this attachment was made, the rebar and forms for the endwalls were placed, and the concrete was poured. The asphalt overlay was then placed followed by the guardrail. The last item on the agenda was the load testing of the bridge. Once testing was completed, the bridge was opened to traffic.

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Chapter 1 – General Information

The bridge over Mill Creek carrying New Salem Road through its course in Union County was first constructed in 1944. The structure spans 42 feet between masonry abutment walls. The bridge superstructure, steel plank flooring on steel girders, has seen many cars and trucks safely across Mill Creek. This structure has since seen many resurfacings and repairs in its lifetime. As with all structures, time and elements will contribute to weakening of components. County Inspectors began to notice settlement of the approach slab, rusting of the metal deck, and cracks in the concrete. As the structure became weakened, NCDOT posted the span, limiting the amount of load the structure could carry to 37 tons (see Figure 1).

Figure 1: Load limit sign

When the structure was recently deemed too weak, due to degradation of the beams and supports, the decision was made to replace the existing superstructure with a composite system. This system is composed of a DuraSpan™ Fiber Reinforced Polymer deck (FRP), produced by Martin Marietta, and steel girders. The replacement process began with the closure of the road on September 17, 2001 and was reopened to traffic on November 20th, 2001. For a more detailed breakdown of the construction schedule, see the timeline in Appendix C.

Chapter 2 – Site Preparation

Once the decision was made to remove the existing superstructure several steps were taken to bring the structure to its current rehabilitated level. The surrounding neighborhood was made aware of the impending closure of the bridge through postings along the route. The structure was closed on September 17, 2001. Once closed, the existing superstructure was removed.

The new superstructure was designed to use 7 - W24X94 in place of the 11 - W21X55 girders being replaced. In preparation for the placement of the new girders a number of modifications were required. The girder seats had to be lowered slightly due to alkali penetration of the stone and mortar used in the original abutment. A jackhammer was used to remove approximately 3” of mortar and stone from the bridge seat at each abutment. In addition to the removal of concrete from the bridge seat, concrete was removed from the front face of each abutment as well, which was required due to longer girder length. This concrete was removed with the jackhammer at the East abutment. However, this proved to be a difficult operation and a contractor was hired to cut the concrete along the West abutment wall. This method took about the same amount of time but resulted in a cleaner and more accurate cut. To prepare a level surface for the bearing, a quick set concrete was mixed and placed at both abutments (see Figure 2).

This concrete type was selected to allow a quick installation. Properly mixed, this concrete sets in 45 minutes and attains a compressive strength of 2000 psi in approximately two hours.

Figure 2: Bridge seat formed and poured

Chapter 3 – Structural Steel Erection

Once the forms were removed, the surfaces were prepared for the placement of the new girders. The centerline of the road was marked at each abutment. This mark was used to lay out the location of the new bearing pads and anchor bolts. It was noticed that the centerline of the road did not fall on the middle of the abutments. The centerline of the road was actually 2” North of the centerline of the abutment (see Figure 3). In order to center the girders on the existing abutments, the superstructure was shifted 2” below the centerline of the road.

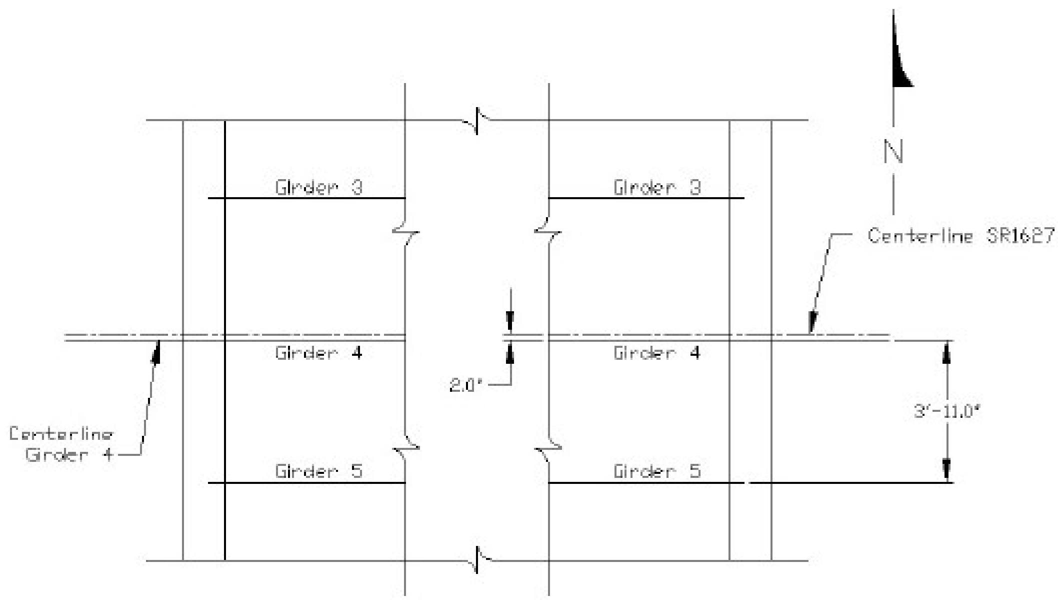


Figure 3: Difference in road and abutment centerlines

The anchor bolts were placed in 1” diameter 10” deep holes drilled into the concrete. The holes were drilled using an electric hammer drill with an elastomeric bearing pad acting as a template (see Figure 4).

Figure 4: Bearing pad used as a template for drilling

Due to time constraints, work had to be halted after the holes were drilled in the first abutment. At the start of the next workday the existing holes had to be dried out with a torch due to the presence of water from a previous rainstorm that weekend. Once all the holes were drilled out and dried, an air compressor was used to blow the dust and debris out of the holes. The holes were then filled one thirds full with HIT-HY 150 epoxy/resin. The anchor bolts were placed, sometimes forcibly, into the epoxy filled holes. Care was taken not to damage the threads when more than hand pressure was required to seat the bolts to the depth of the hole (see Figure 5).

Figure 5: Nut being used to protect threads from damage

After the epoxy had time to cure, the W24X94 steel girders were brought to the site. Using a crane onsite, the center girder (G4) was removed from the truck and placed on blocks to the side of the trailer (see Figure 6). Blocks were used to protect the strain gages that were previously installed on the bottom of the girder. This girder was then fitted with a "lifeline" that was used for protection when walking on the girders. This girder was lowered carefully onto the anchor bolts allowing workers to snug the nuts and washers onto the bolts. The remaining girders were then placed in the following order: G3, G5, G2, G6, G1, and finally G7 (See Appendix A).

Figure 6: Girder placement on blocks

Once the girders were in place, plywood panels were cut to fit on top of the bottom flange of the girder. Due to the wide spacing of the new girders some intermediate support was required. This support was provided by 2X4 construction grade studs placed under the panels at the center and at the ends. The panels were attached to the supports using wood screws. Once this temporary flooring was in place, the lifeline attachment was no longer a necessity (see Figure 7).

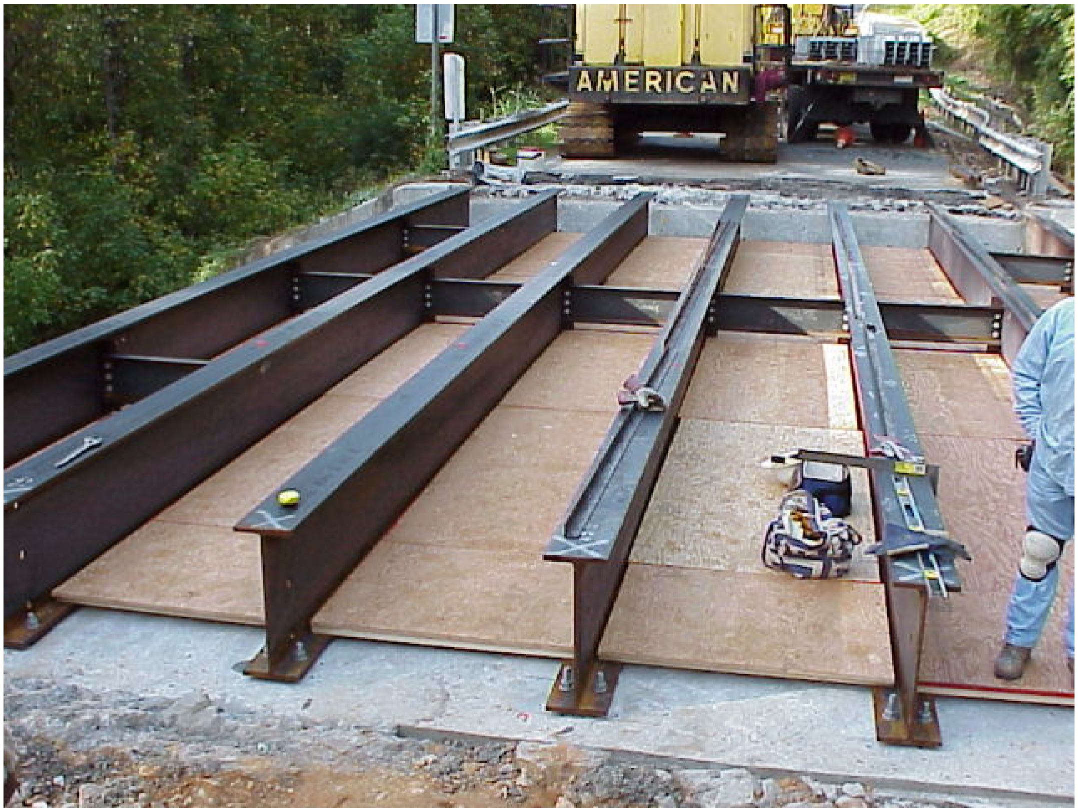


Figure 7: Girders and temporary flooring in place

After the girders were secured, and the temporary flooring was in place, the diaphragms (10 - C12X20.7) were bolted into place (see Figure 8). The diaphragms were bolted to a 3/8" thick connector plate welded to the web of the girder. For more information on the connector plate, see the Connector Plate Detail on Sheet 2 of the NCDOT Preliminary Bridge Plans supplied in Appendix A. The holes in the girder were located and placed by the fabricator of the girders. For more information on the location of the diaphragm, see the Diaphragm Detail on Sheet 1 of the bridge plans supplied in Appendix A. The connection was made using 7/8" diameter bolts. The bolts were classified as HDG Structural Screws made from A325 steel. They were 3" long and required both a nut and a washer.

Figure 8: Diaphragm bolted in place

After the cross members were in place, two events occurred simultaneously. First, the posts and blocks used to attach the barrier rail were installed on the exterior girders. These members were pre-assembled on the back of a boom truck and lowered into position (see Figure 9). The same type of bolts used in the cross member connection, were used to secure the post and block to the girder. For more information on the members used in the assembly and the bolt patterns, see Sheet 3 of the bridge plans in Appendix A.

Simultaneously, the angles (L2X2) used to separate the composite deck from the girder were installed. The angles were positioned so as to be level across the bridge transversely, and angled so as to follow the camber of the bridge along the longitudinal direction. The angles were welded to the girders top flange using a ¼” fillet weld placed every 12” (see Figure 10). For more information on the angles, see the Flange Detail on Sheet 2 of the bridge plans located in Appendix A.

The next step in the process was the installation of the suspended scaffolding. This scaffolding was attached to the bottom flanges of two girders (G2 and G6). Once in place, this scaffold allowed access to the bottom of the bridge superstructure.

Figure 9: Post and block assembly

Chapter 4 – GFRP Panel Installation

During the next phase of the construction process, the composite deck panels were installed. The bridge deck was designed to use five DuraSpan™ FRP panels. Each panel was approximately 8' X 25'-4", creating a 40' X 25'-4" composite deck across the girders. Each panel was composed of pultruded tubes, which were bonded together. The tubes created a "honeycomb" type cross-section in the panel, with the tubes running perpendicular to the girders.

The process of placing the panels began with the installation of angles at the east end of the girders. These angles were welded in place to allow the end of the FRP panel to fit flush with the end of the steel girder (see Figure 10).

Figure 10: Angles at end of girders

A standard silicone caulk was used to seal any gaps between the longitudinal angles, and the girder. The same caulk was placed on the top of the longitudinal angles to act as a sealant between the FRP panel and the angle (see Figure 11). The purpose of making the seal was to prevent grout from escaping the shear stud pockets, thus creating a void in the concrete.

Figure 11: Caulk being applied to angles

The DuraSpan™ FRP panels were installed in accordance with the Martin Marietta Installation Manual (see Appendix B for complete instructions). The bonding surfaces (as indicated in Figure 12) of the panels were first cleaned with acetone to remove any oils that would affect the bond of the adhesives.

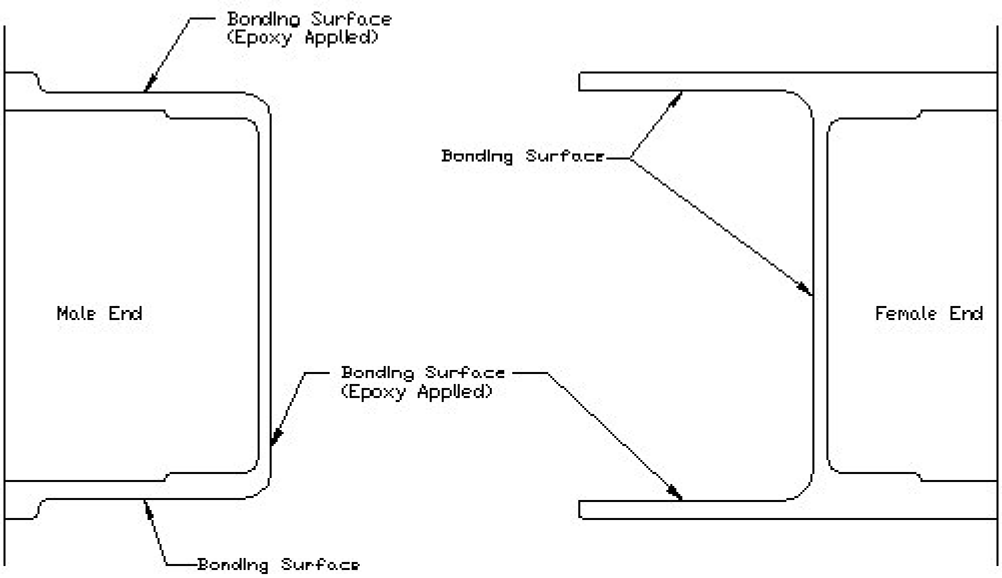


Figure 12: Panel joint

The panels were then prepared for the epoxy application with a coat of primer applied to the bonding surfaces. Martin Marietta supplied both the primer and the epoxy, which were manufactured by Master Builder Technologies. The primer consisted of two parts, part A and part B, mixed in the proportion of two parts A to one part B per volume. The two components were poured into a bucket and mixed to an even consistency using an electric drill fitted with a mixing tool. The mixture was applied to the bonding surfaces evenly using a small paint roller (see Figure 13). The primer was allowed to set for approximately 30 minutes before the application of the epoxy.

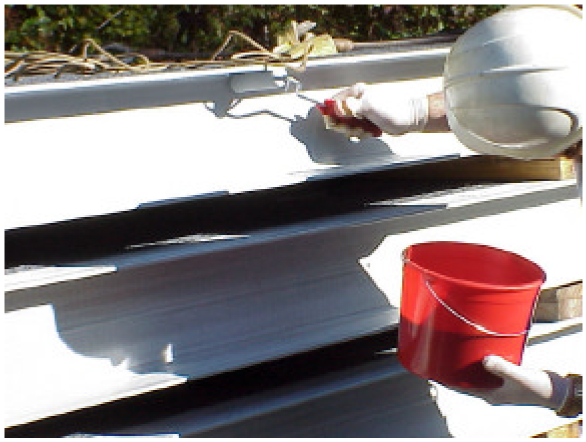


Figure 13: Primer Application

While the primer was curing, straps were threaded through the shear stud holes in the first panel. These straps were approximately 4” wide, 10’ long, flat, nylon tow straps. There was one strap placed at each corner of the panel. Once the primer had set, a crane was used to position the panels on the structure. Care was taken to align the panel between the post and block assembly. The panel was lowered on the girder and slid against the stops at the end (see Figure 10). Once in position longitudinally, this panel was adjusted in the transverse direction as well.

After the first panel was positioned, the next panel was prepared for assembly. This preparation consisted of first attaching the lifting straps. Secondly, epoxy was mixed to create a permanent bond between the panels. The epoxy was mixed with the same ratio as the primer, and thoroughly mixed using the same electric drill. Once mixed, the epoxy was applied to the male end of the next panel to be installed, and to the female end of the panel already positioned on the girders. The epoxy for the female end was placed on the “bottom lip” of the bonding surface only. See Figure 12 for joint details. On both panels, the epoxy was initially placed using a flat trowel, then spread using a ¼” grooved trowel (see Figure 14).

Figure 14: Epoxy after spreading

Once the epoxy was applied to both panels, the crane lowered the new panel into position. The panel was aligned visually in the transverse direction. After the ends were brought into contact and hand pressed together, jacks were used to press the panels together. Standard hydraulic bridge jacks were used with manual pumps. An angle was spot welded to the girder to provide a solid support for the jack. Then, the jack was positioned so the stroke of the piston would run longitudinally along the girder, pressing against a wood block placed between the head of the piston and the panel edge (see Figure 15). Two jacks were used, one on G2, and the other on G6. The jacks were used to press the panels together and squeeze out all excess epoxy, which was then scraped off using a putty knife.

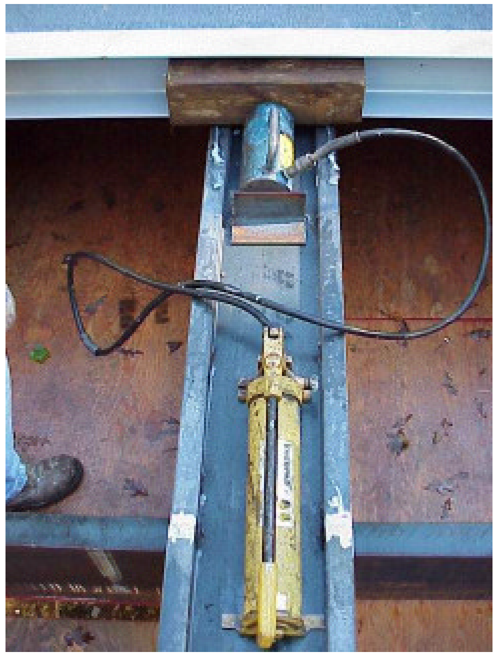


Figure 15: Jack Placement

While the jacks were holding the pressure, a 5/8" hole was drilled through the panel joint at a point roughly centered between two girders (see Figure 16). The holes were drilled between girders G1 & G2, and between G6 & G7. Then, an epoxy coated composite dowel was driven into the hole to secure the two FRP panels while the adhesive cured (see Figure 16).

Figure 16: Dowel Placement

Once the dowels were in place, the jacks were released and the temporary angle braces removed. This process of epoxy application, panel placement, jacking, drilling and doweling was repeated for all the remaining panels. The jacking of the last panel required some modification. The last panel covered the ends of the girders, so the jack brace could not be welded to them. A brace was made from scrap wood on-site to transfer the jacking force to the approach pavement (see Figure 17).

Figure 17: Jack Placement at End Panel

After being allowed to set and cure overnight, the panel joints were prepared for the joint tape. This preparation consisted of grinding away any excess epoxy that expanded out of the joint during the curing process. Once this was done, acetone was used to clean the top surface of the joints of any oils that would interfere with the bonding of the tape to the deck surface.

The next step was the measurement of the fiber strips. The material for the strips was brought to the site on a large spool. The spool was unrolled across the width of the deck panel and cut, allowing for an overhang at the ends (see Figure 18). The material itself was a triax E-glass fabric produced by Johnson Industries. The triax term comes from the direction of the fibers in the fabric. The fibers were oriented in a [90/+45/-45] pattern. This material was placed over the deck panel joint and bonded in place with a vinylester material (Atlac 580). This material was chosen due to the flexibility of the material.

Figure 18: Joint tape rolled out

The bonding material consisted of two parts, the first part being the resin, and the second part being the catalyst. Due to the warm temperature present when the strips were being placed, only a small batch (just enough to do one strip) was mixed at a time. Approximately one gallon of resin (Promoted Hectron FR992) was mixed with 30 mL of catalyst (Cadox C50A) for each strip.

Once mixed, some of the resin was poured onto the deck joint. The material was then spread out in a thick layer over the area where the fabric would be placed (see Figure 19). Then, the fabric was placed over the joint. A grooved steel roller was used to press the material into the underlying resin (see Figure 19). Another layer of resin was then brushed on the top surface of the fabric. This process resulted in the material being completely soaked, and in full contact with the panels on either side of the joint.

Once the fabric was in place, any extra material at the overhang was removed. This process was repeated at each joint on the deck surface. Care was taken during the process not to have any unnecessary foot traffic on the deck surface. The strips were cured overnight before work was resumed.

Figure 19: Resin Application

Chapter 5 – Deck-to-Girder Connection

Once the panels were completely connected to each other, the connection between the panels and the deck was established. This connection was achieved through the use of shear studs. The deck itself was manufactured with pockets along the length of the girder, which allowed the placement of shear studs. Each pocket was designed to have three ¾" diameter shear studs (see Figure 20).

Figure 20: Shear stud pocket

The steel studs were installed using a specialty tool designed specifically for welding studs. The Division 10 bridge maintenance department did not have a welder of sufficient capacity to weld the large studs, so a contractor was hired to place the studs.

Once the contractor arrived to the job site, there was a minimal amount of preparation for the "stud shooting". First, the welder was set at 1700 Amps and a stud was welded in the first pocket. This stud was then tested to check the quality of the bond. This test consisted of bending the stud a few inches in the transverse direction of the bridge, then bending it an equal amount in the opposite direction. This side-to-side movement produces a large amount of stress on the weld, and it is believed that if the weld can withstand this large movement, then it is fully attached to the girder.

With the amperage set, the studs were positioned in place to allow the welder to move quickly from one pocket to the next. Insulators, which are used to keep the heat produced from the weld localized to the stud, were placed in the pocket at each location a stud was desired. The studs were set beside each opening (see Figure 21) resulting in an efficient installation procedure.

Figure 21: Studs arranged for welding

There were only two complications encountered, both of which were related to a shortage of material. The welding crew was short by approximately a dozen studs, which meant that there were several pockets that only received two studs. The second problem was a shortage of insulators. The welding crew had some leftover from a previous job, and used those to finish the work. Once all the welding was completed, there was some discussion as to whether the insulators around the shear studs would interfere with the bond between the studs and the grout scheduled to be pumped into the opening. It was decided to break the insulators away from the studs, to allow the grout to completely cover the area around the base of the stud.

Once the studs were in place, the next step in the connection was the placement of the grout in the stud pockets. The grout pump was primed with Slick Willy to promote a better flow of the grout. The grout itself was mixed in a gasoline powered rotary mixer at a ratio of 50 lbs of grout to ½ gallon of water. The materials were allowed to mix for approximately 10 minutes before being placed in the hopper of the pump. The NCDOT personnel placed several batches of the mix into the pump before starting the process to ensure an adequate supply. After checking the slump of the mixture, which was approximately 11”, the process was started at the girder line farthest from the pump. Each pocket was filled to deck level before moving to the next pocket in the girder line (see Figure 22). The crew noticed that as they worked down the line, previous pockets had settled down below deck level. These pockets were back filled manually, using a bucket of grout and a trowel (see Figure 22). According to the manufacturer, the grout had a setting time of three hours, and a curing time of one day.

Figure 22: Grout placement and finishing

Chapter 6 – Semi-Integral Endwall Construction

The next step in the construction of the bridge was the construction of the concrete end wall. The end wall was designed to be semi-integral with the deck slab, i.e. the deck would be tied to the concrete abutment. This tie was made through the use of rebars passed through holes pre-cored in the deck (see Figure 23). The reinforcement was then tied into the cage placed around the girders and bearing pad. For a detailed description of the reinforcement schedule, see Appendix A.

Figure 23: Endwall Connection

Once the reinforcement was in place, forms for the concrete were cut and nailed into position. The formwork consisted of a plywood interior surface being braced by 2" lumber. After fully bracing the formwork against possible outward movement, the concrete was ordered.

Metromont Materials supplied the concrete. Two trucks were required, one at each abutment. The first truck arrived at the West abutment with 5 yards of class AA concrete. The concrete was poured directly from the truck into the forms. A mechanical vibrator was used to remove any trapped air from the mixture as it was placed (see Figure 24). The surface was hand finished using a trowel. The same process was repeated on the East abutment. In order to test the 28-day strength of the mix, three cylinders were collected from each truck. The samples were taken in accordance with ASTM C31-91.

Figure 24: Concrete Poured at Endwall

Chapter 7 – Roadway Construction

Once the superstructure was finished, the next step in the construction process was to prepare the approaches to the bridge. The area surrounding the end walls had been excavated to allow access to the abutment. Therefore, the soil had to be replaced and compacted in those areas. Once the soil was in place, the structure was ready for the asphalt pavement. The I-2 asphalt was placed in 2” layers (or lifts). Three layers of binder were placed in the approaches to raise them to the desired level. After placing three layers of binder in both approaches with a layer on the deck of the bridge, crews began to place the asphalt. Each lift of binder and asphalt was compacted by a vibratory drum roller before the next layer was applied (see Figure 25).

Figure 25: Vibratory Drum Roller

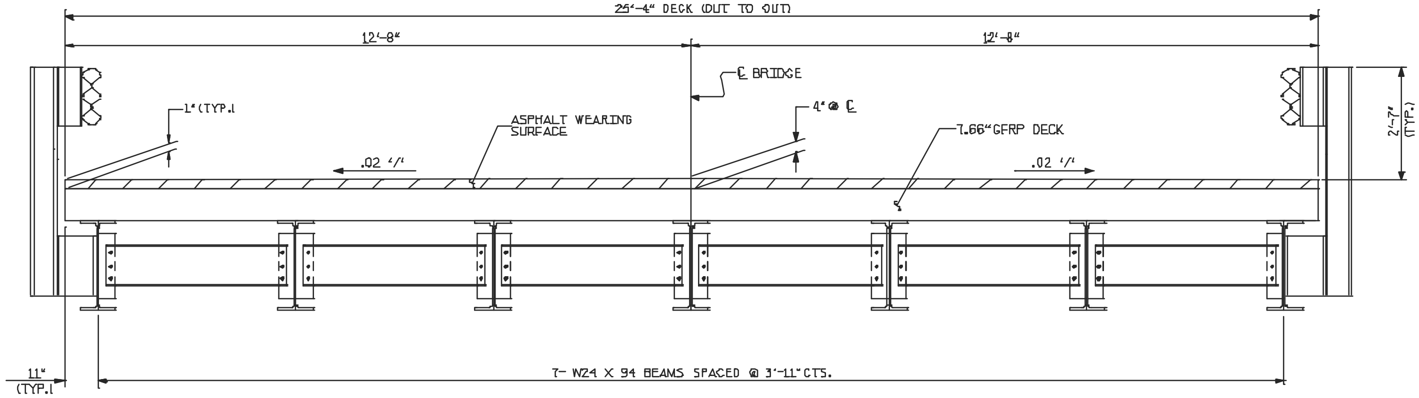
With the raised level of the approach, some grading was required to bring the shoulder of the road up as well. In order to set the new shoulder height, the existing barrier rail had to be removed. Soil was placed along the side of the road and leveled out with a motorgrader (see Figure 26).

Figure 26: Motorgrader Finishing the Shoulder

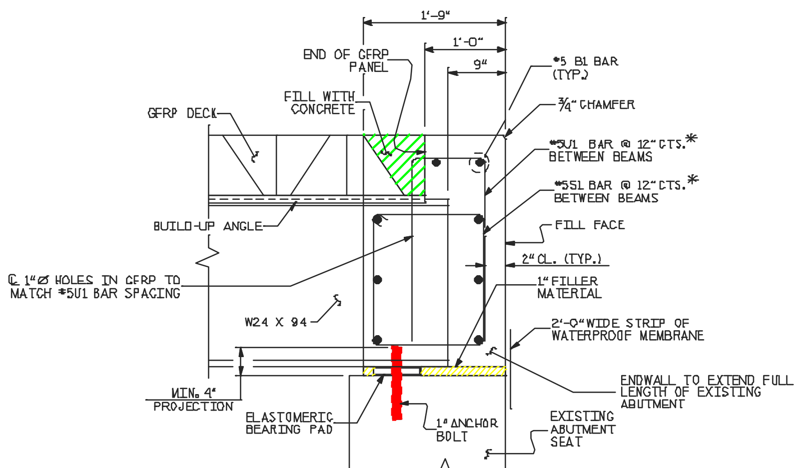
Upon completion of the grading, the road surface was brushed off with a combination of brooms and a mechanical brush.

The next phase was the installation of the guardrail. NCDOT personnel attached the guardrail to the posts along the side of the bridge, and hired a contractor to install the posts leading up to the bridge from both sides. The contractor used a hydraulic ram to drive the posts into the soil, and attached the rail using an air impact wrench. Once the guardrail was in place, crews were able to apply the pavement markings, and the bridge was ready to be opened to traffic. In the period of a few months, the Mill Creek crossing was upgraded through the use of a composite deck.

Appendix A – NCDOT Bridge Plans



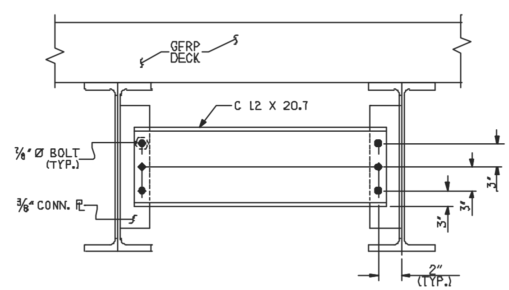
TYPICAL SECTION



SEMI INTEGRAL ENDWALL DETAIL

* PLACE TWO ADDITIONAL "U" AND "S" BARS IN END WALL OUTSIDE EXTERIOR GIRDERS

PRIOR TO DRILLING HOLES FOR ANCHOR BOLTS, VERIFY DISTANCE OF 39'-6" BETWEEN CENTERLINE OF BEARINGS.



DIAPHRAGM DETAIL

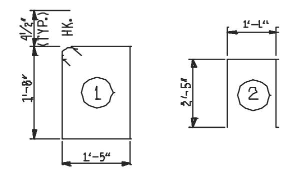
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

BILL OF MATERIAL

BAR	NO.	SIZE	TYPE	LENGTH	WEIGHT
B1	16	#5	STR.	24'-8"	412
S1	56	#5	1	6'-11"	404
U1	56	#5	2	5'-11"	346

TOTAL REINFORCING STEEL (LBS.)	1,162
CLASS AA CONCRETE (CU. YDS.)	8.0
STRUCTURAL STEEL (APPROX. LBS.)	27,560
1" X 6" X 8" BEARING PADS (NO.)	14
1" FILLER MATERIAL (SQ. FT.)	90
25'-4" X 10' GFRP PANELS (NO.)	4
1" Ø X 1'-2" ANCHOR BOLTS (ADHESIVELY ANCHORED) (NO.)	28
7/8" Ø H.S. BOLTS FOR DIAPHRAGMS AND LOWER OFFSET BLOCKS (INCLUDING DIRECT TENSION INDICATORS) (NO.)	252
5/8" Ø H.S. BOLTS FOR RAIL (NO.)	128
12 GA. ANGLE (LIN. FT.)	648
3/4" DIA. X 5" ANCHOR STUDS (NO.)	420
RAIL:	
W8 X 31 X 5'-1 1/4" POSTS (NO.)	16
W6 X 15 X 1'-8" OFFSET BLOCKS (NO.)	16
W12 X 26 X 1'-7" OFFSET BLOCKS (NO.)	16
THRIE BEAM RAIL (LIN. FT. +/-)	90
WTR SECTIONS (NO.) **	4

BAR TYPES



ALL BAR DIMENSIONS ARE OUT TO OUT.

** STANDARD GUARDRAIL POSTS AND RAIL FOR APPROACH ROADWAY ARE NOT INCLUDED IN THIS BILL OF MATERIAL.

REHABILITATION OF BRIDGE NO. 22

PROJECT NO. ____

UNION COUNTY

STATION: ____

SHEET 1 OF 3

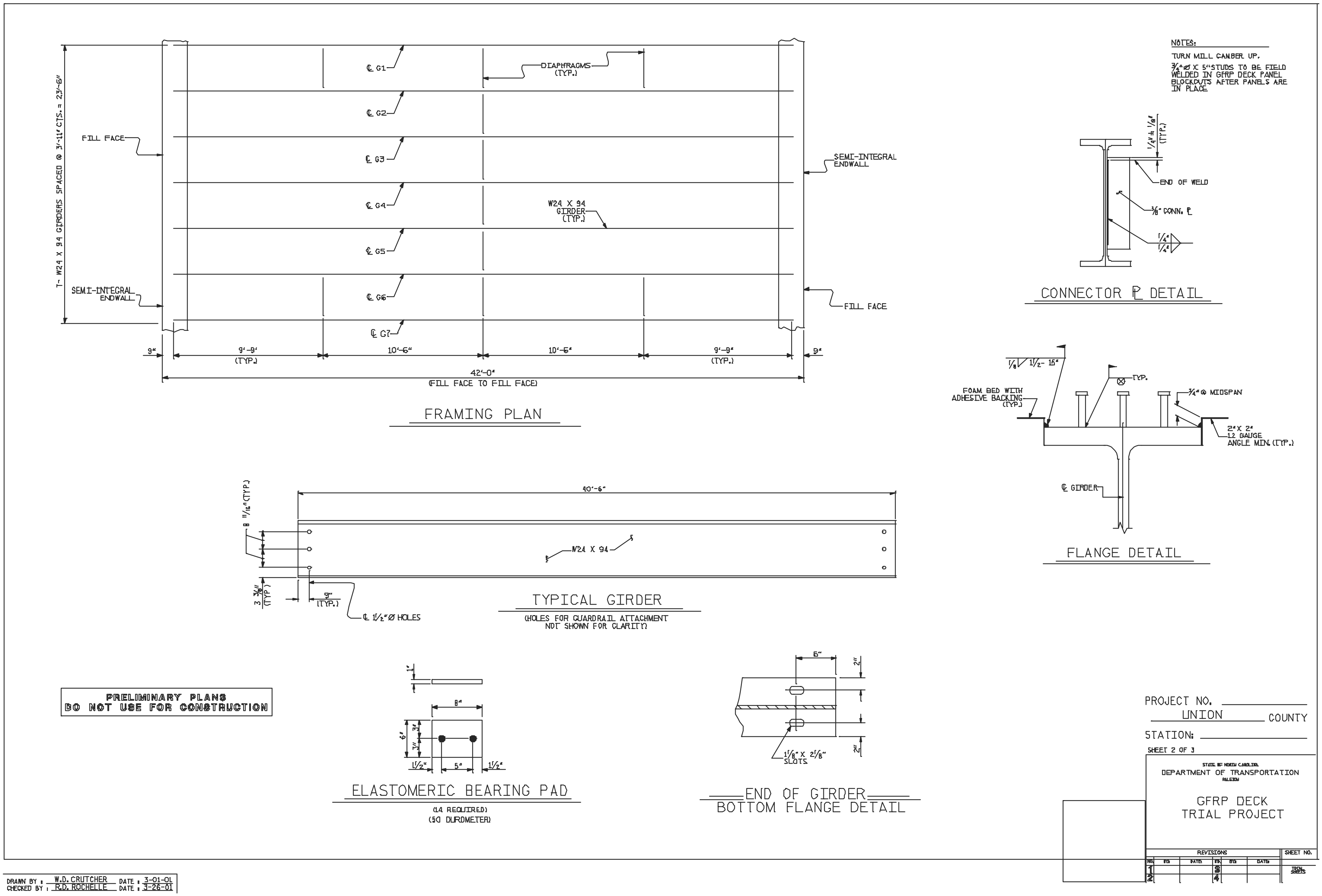
STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

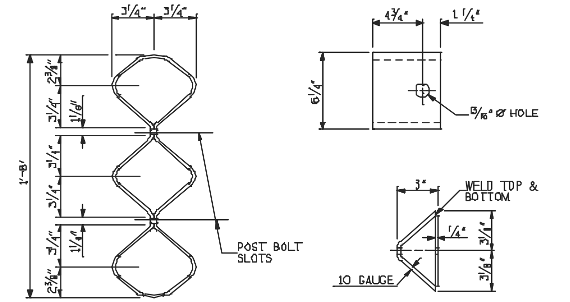
GFRP DECK
TRIAL PROJECT

SR 1627 OVER MILL CREEK

REVISIONS						SHEET NO.
NO.	BY.	DATE	NO.	BY:	DATE:	
1			3			TOTAL SHEETS
2			4			

DRAWN BY : W.D. CRUTCHER DATE : 3-01-01
CHECKED BY : H.D. ROCHELLE DATE : 3-26-01


NOTES:
TURN MILL CAMBER UP.
3/4"Ø X 5" STUDS TO BE FIELD WELDED IN GFRP DECK PANEL BLOCKOUTS AFTER PANELS ARE IN PLACE.
7- W24 X 94 GIRDERS SPACED @ 3'-11" CTS. = 23'-6"
FILL FACE
SEMI-INTEGRAL ENDWALL
℄ G1
℄ G2
℄ G3
℄ G4
℄ G5
℄ G6
℄ G7
DIAPHRAGMS (TYP.)
W24 X 94 GIRDER (TYP.)
9"
9'-9" (TYP.)
10'-6"
10'-6"
9'-9" (TYP.)
9"
42'-0" (FILL FACE TO FILL FACE)
FRAMING PLAN
END OF WELD
3/8" CONN. ℙ
1/4" ± 1/8" (TYP.)
CONNECTOR ℙ DETAIL
1/8 1/2- 15"
TYP.
3/4"Ø MIDSPAN
FOAM BED WITH ADHESIVE BACKING (TYP.)
2" X 2" 12 GAUGE ANGLE MIN. (TYP.)
℄ GIRDER
FLANGE DETAIL
40'-6"
8 11/16" (TYP.)
W24 X 94
3 3/16" (TYP.)
9" (TYP.)
℄ 1 1/2"Ø HOLES
TYPICAL GIRDER
(HOLES FOR GUARDRAIL ATTACHMENT NOT SHOWN FOR CLARITY)
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
1"
8"
6"
3"
3"
1 1/2"
5"
1 1/2"
ELASTOMERIC BEARING PAD
(14 REQUIRED)
(50 DUROMETER)
6"
2"
2"
1 1/8" X 2 1/8" SLOTS
END OF GIRDER
BOTTOM FLANGE DETAIL
PROJECT NO.
UNION COUNTY
STATION:
SHEET 2 OF 3
STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH
GFRP DECK
TRIAL PROJECT
REVISIONS
SHEET NO.
DRAWN BY : W.D. CRUTCHER DATE : 3-01-01
CHECKED BY : R.D. ROCHELLE DATE : 3-26-01



TUBULAR THRIE BEAM & SPACER DETAILS

NOTES:

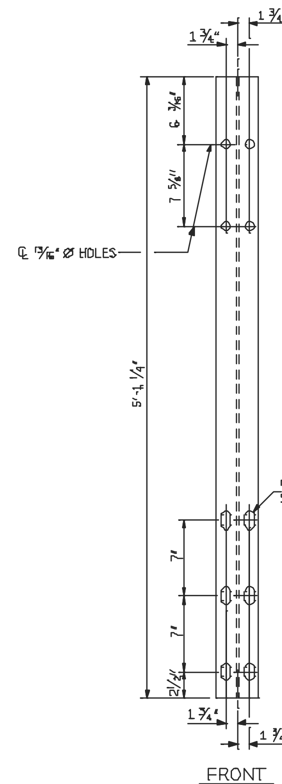
FABRICATOR TO PUNCH HOLES IN EXTERIOR GIRDERS FOR ATTACHMENT OF W12 X 26 OFFSET BLOCKS.

STRUCTURAL STEEL TO BE AASHTO M270 GRADE 50W.

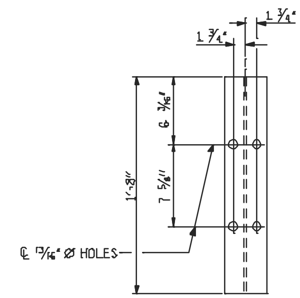
ALL BOLTS TO BE ASTM A325, AND GALVANIZED.

GUARDRAIL SHALL CONFORM TO THE NCDOT STANDARD SPECIFICATIONS EXCEPT AS NOTED ON THE PLANS.

DIRECT TENSION INDICATORS SHALL BE USED WITH ALL 7/8" Ø H.S. BOLTS

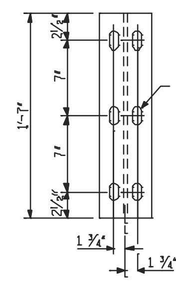


W8 X 31 RAIL POST



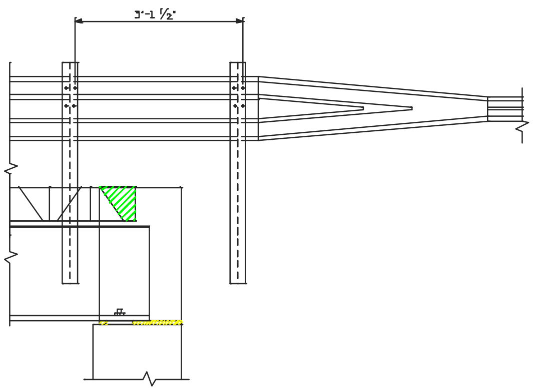
W6 X 15 OFFSET BLOCK

(HOLES IN BOTH FLANGES)

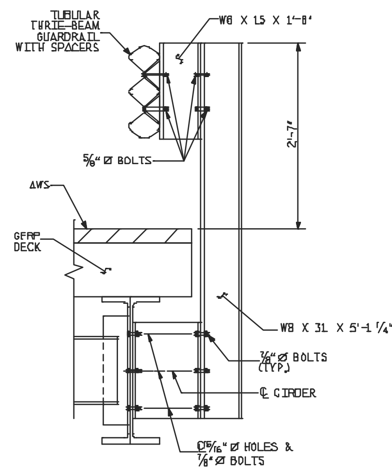


W12 X 26 OFFSET BLOCK

(SLOTS IN BOTH FLANGES)



RAIL ELEVATION

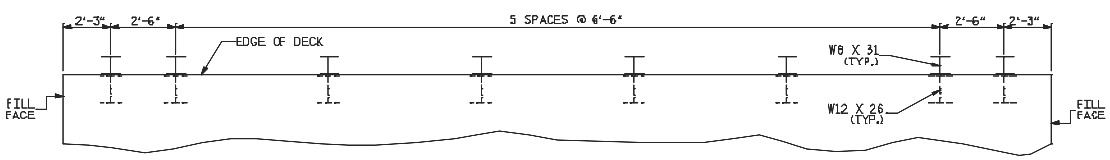


RAIL DETAIL

RAIL POSTS AND OFFSET BLOCKS TO BE GALVANIZED.

BOLTS FOR RAIL TO BE MECHANICALLY GALVANIZED.

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION



RAIL POST SPACING PLAN

(TYPICAL EACH SIDE)

PROJECT NO. ______
UNION COUNTY
STATION: ______
SHEET 3 OF 3

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

GFRP DECK
TRIAL PROJECT

REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	
1			3			
2			4			

DRAWN BY : W D CRUTCHER DATE : 03-14-01
CHECKED BY : R.D. ROCHELLE DATE : 3-26-01

Appendix B – Martin Marietta Installation Guide

Martin Marietta Composites

Installation Guide

DuraSpan™ FRP Bridge Deck Panels

June 2001

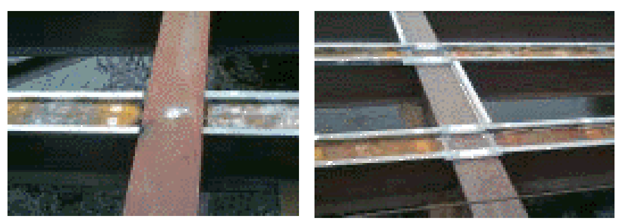
Installation Procedures

Shown below is a brief pictorial illustrating the major tasks for installation of the *DuraSpan*™ deck panels.

1. Unloading, storage of panels

Site handling and erection shall be performed with acceptable equipment and methods, and by qualified personnel and in accordance with the manufacturer's recommendations. The panels shall be lifted and supported during stockpiling and erection operations only at the lifting or supporting points, as shown on the shop drawings, and with approved lifting devices. The panels shall be kept flat and true to prevent warping or twisting of the panels during lifting and storing. The panels shall not be turned or placed on their sides or with the top surface down. Lifting of the panels from one edge will not be permitted. All panels shall be stored off of the ground and protected with covers that are impervious to sunlight and weather in order to provide protection from ultraviolet light and keep the panels clean and dry. Stacked panels shall be supported on unyielding supports and shall be separated by battens across the full width of each panel. Panels will arrive on truck as requested by the contractor.

2. Preparations prior to installation of deck panels



Steel flanges on stringers and floorbeams shall be prepared in accordance with DOT specifications, including grinding at stud locations if necessary. Light gage stay-in-place steel angles are the preferred method of forming the haunches. These are the same angles that are used for the stay-in-place forms for concrete decks and shall be designed to support the weight of forklift, deck, and construction loads. Typically elevations are shot at 1/10th points along the beams and the height of the haunch is determined by subtracting this elevation from the finished grade elevation minus the deck and overlay depths. On framing systems that have a transverse floorbeam/longitudinal stringer configuration as shown, the angles will be typically be installed on the stringers only but the haunch will be continued over the floorbeams as shown. On the job shown, this was accomplished with foam and tape.

3. Installation of first panel

Proper placement of the first panel is very important. The panel needs to be placed with the proper alignment and secured (bolted) so there is no movement when other panels are jacked against it. Suggest surveying to make sure the first panel is aligned properly as well as surveying the centerline of structure. The panels will have the centerline marked on them, and at various times during installation the alignment of the panel centerline may be checked with the surveyed centerline of structure.

4. Application of epoxy adhesive (liquid primer and paste coat)

Prior to application of the adhesive, both surfaces of the bondlines shall be cleaned with acetone. A liquid primer will be rolled on to both mating surfaces (100% coverage) and allowed to tack up. Upon sufficient set of the primer coat, the paste coat will be applied on the vertical web and flanges (100% coverage on one side of the joint only) using 3/16" notched trowels. MMC will supply the adhesive (probably 3-4 gallon buckets) and the contractor will apply it. MMC will keep track of temperature and time to ensure proper working time is not exceeded. Working time will vary depending on temperature, but in general a minimum one hour working time can be achieved.



5. Lifting/placing panels

Type 1 - Thru-truss or long span structures.
For thru-truss or longer span structures where cranes do not have sufficient reach to install the panels, panels may be lifted and placed with the lightest weight equipment (typically forklifts) possible. For this type of installation, the specific piece of equipment shall be approved by the manufacturer. In order to help spread the tire load over the wet bondlines, timber/steel planking running the full length of the tire contact area will be required as shown in the following pictures. A steel plate (or other acceptable means) shall also be placed at the beginning of the bridge to protect the unsupported edge of deck during installation.



Type 2 – Short to medium span structures.
For short to medium span structures, a crane with sufficient reach to place all panels without sitting on the bridge is the preferred option and should be used whenever possible. This method not only protects the integrity of the bondline while it cures but also allows for smaller angles and welds to be used for the haunches.



6. Jacking the panels

The panel field joints overlap 4" (tongue-in-groove type joint), so the panels will need to be slid 4"-6", depending on how close they are lowered into place. Panels are jacked into place by means determined by the contractor. In the past, jacks welded to a steel plate were clamped to the top flange or the angle supports. There are several other options which MMC can share with the contractor, but ultimately the method for the placing of the panels is the responsibility of the contrator. MMC will work with the contractor with his proposed method. For most bridges, two jacking locations each side of the centerline will be sufficient. MMC will provide timbers that will fit the shape of the deck to jack against. The panels should be jacked completely together so that the lip of the female end seats flush against the top deck surface on the male end. While the jacking pressure is still being applied, permanent FRP dowel bars are installed in the lips of the field joints prior to releasing jack pressure to protect the integrity of the bondline while it cures. MMC will provide the FRP dowel bars. After the dowel bars are in place and the jacking pressure has been released, all excess adhesive that has been squeezed out of the bondline shall be struck off flush with the top surface of the deck with a scraper before the adhesive cures.

7. FRP splice strips on panel field joints

After all the panels are in place and the field bondlines have sufficiently cured (usually overnight), FRP splice strips are installed over the bondlines. These strips will be 32oz. triaxial fabric and will be delivered to the site pre-cut to 7" wide and to the proper length (will wrap over vertical edge of deck). Steps for the installation of these strips are as follows:

1. The bonding surface will be prepared in the shop but will need to be sanded (40-60 grit sandpaper) or ground lightly in the field to remove all contaminants and ensure a good bonding surface (sand the section until all of the gloss is eliminated and the surface is thoroughly roughened).
2. After sanding/grinding, the surface will need to be blown as clean as possible with an air compressor and wiped with acetone wipe prior to application of the strips. Allow acetone to completely dry.
3. A vinyl ester resin and steel rollers will be used to wet out the fabric. Catalyze and mix the resin in one gallon containers. The pot life of the resin mix is temperature dependent. Therefore, the amount of catalyst must be modified according to air temperature and desired working time. The following charts depict the proper catalyst and promoter amounts and are based on specifications for Reichhold 580-05 resin systems:

Reichhold 580-05 Mixing Instructions per Pound of Resin			
Temp (F)	Gel Time (minutes)	MEKP (9%)	CoNaph (6%)
		%	%
40	30-40	2.4	0.7
50	30-40	1.8	0.6
60	20-30	2.4	0.6
	30-40	1.8	0.6
	40-50	1.2	0.6
75	15-25	1.8	0.4
	20-30	1.4	0.4
	30-40	1.2	0.4
90	15-25	1.2	0.3
	20-30	1.2	0.2
	30-40	0.9	0.2

Resin density 8.5 lbs/g

Gel Time 30-40 minutes					
Gallons of resin @75 F	Lbs of resin @75 F	MEKP (9%)	MEKP (9%)	CoNaph (6%)	CoNaph (6%)
(gal)	(lbs)	%	cc or ml	%	cc or ml
1	8.5	1.2%	46.31	0.4%	15.44
2	17	1.2%	92.62	0.4%	30.87
3	25.5	1.2%	138.92	0.4%	46.31
4	34	1.2%	185.23	0.4%	61.74
5	42.5	1.2%	231.54	0.4%	77.18
6	51	1.2%	277.85	0.4%	92.62
7	59.5	1.2%	324.16	0.4%	108.05
8	68	1.2%	370.46	0.4%	123.49
9	76.5	1.2%	416.77	0.4%	138.92
10	85	1.2%	463.08	0.4%	154.36

Notes:
- Add the required promoter and catalyst to the desired amount of resin. Catalyze only one gallon at a time.
- Mix resin/catalyst for not less than one minute. A drill and a high shear mixer should be utilized.
- Never mix CoNaph with MEKP in the same container.

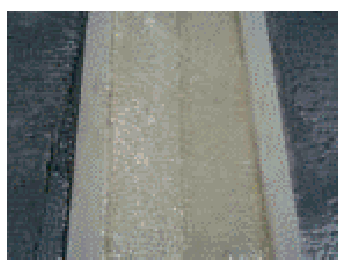
4. After the entire splice surface is coated with resin, lay the 32 oz. fabric (chop side down) and roll out with the steel rollers.
5. Roll the mat in the direction of the joint, then roll the mat perpendicular to the joint. This will force out the air. Resin will soak up through the fabric. If dry spots appear, apply additional resin on the top of the fabric as necessary if there are still dry spots and roll out until fabric is totally wet out.
6. If there is excess resin on the top or sides, soak up the excess resin with a paintbrush

MMC will provide all materials and technical oversight for the installation of these strips and the contractor will be responsible for the labor and equipment. These strips will need to sufficiently cure (usually overnight) before workers are allowed to walk on them. Prior to installing the overlay, light sanding with 40-60 grit sandpaper is recommended for proper adhesion.








8. Installation of shear studs (deck-to-girder connections)

After the splice strips have cured, the conventional headed shear studs may then be welded to the beams. After all of the studs are in place and have been tested in accordance with DOT specifications, the non-shrink grout may be placed.



9. Installation of non-shrink grout pockets and haunches

After the shear studs have been installed, the stud pockets and haunches may then be grouted. The grouting operation shall meet the following specification. *SikaGrout* 212 has been tested and used in the past, but alternate grouts meeting the specification are acceptable. The grout will flow through the stud pockets to fill in the variable depth haunch between the bottom of the deck and the top of the beam. Grout will flow underneath deck to adjacent hole, then fill grout pockets. It is very important to get the haunches and cavities completely filled without any voids. A mobile mixer located off the end of the bridge and a pump to get the grout out on the bridge is highly recommended. Care should also be taken to prevent spillage onto deck surface (plastic was used on previous jobs).



NONSHRINK GROUT FOR HAUNCHES AND SHEAR STUD POCKECTS

1.0 Materials and Mixing.
The nonshrink grout shall be a flowable nonmetallic grout meeting the requirements of ASTM C 1107 Grade C.

The mixture shall have a flow of 125% to 145% when tested in accordance with ASTM C 109M. The grout shall have a maximum allowable expansion of 0.1% at 3, 14, and 28 days when tested in accordance with ASTM C 1090. The expansion at 3 and 14 days shall not be greater than the expansion at 28 days.

The grout shall have a compressive strength of not less than 34 MPa at the age of 7 days and 40 MPa at the age of 14 days when tested using the applicable portions of ASTM C 109M. The compressive strength specimens shall be produced from a mixture of the dry grout and sufficient water to produce a flowable mixture. The initial set shall not be less than 60 minutes when tested in accordance with ASTM C 403M.

The resistance of the grout to freeze thaw shall be such that it maintains a relative dynamic modulus of elasticity of not less than 80% after 300 cycles when tested in accordance with AASHTO T 161, Procedure B.

The grout product will be accepted provided that certified test data is submitted that reflects conformance with the requirements stated herein.

Mixing shall be done with rotating paddle-type mixing machines and shall be continued until all ingredients are thoroughly mixed. Once mixed, grout shall not be retempered by the addition of water and shall be placed within 1 hour.

2.0 Forming and Placing.
The forms shall be constructed of wood, metal or other material approved by the Engineer. The forms shall be constructed to retain the grout without leakage. An adhesive-backed foam bed shall be placed on the tops of the forms in contact with the deck panels in order to seal the interface. The forms shall be designed to remain true to shape and rigidly support the weight of the FRP panels and all materials, equipment and personnel necessary for placement of the grout. Forms shall be set and maintained to the lines and grades specified on the plans and in a manner approved by the Engineer until their removal.

All tie rods, bolts, anchorages and other forming hardware which is incorporated into the haunches shall be galvanized. Tie rods, bolts and anchorages, within the forms shall be constructed so as to permit their removal to a depth of at least 40 mm from the face without injury to the concrete. Wire ties, when used, shall be cut back at least 15 mm from the face of concrete upon removal of the forms. All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left will be of the smallest practical size.

If stay-in-place forms are not used, the forms should be lined or coated with a bond-breaker approved by the Engineer. The forms shall not be removed until the grout has hardened sufficiently that it will not be damaged and until the Engineer has approved such removal.

The grout shall be placed in a manner and sequence such that all voids are completely filled. Vent holes or tubes in the formwork shall be sized and located as necessary to prevent air entrapment. If the Contractor's methods of placement do not achieve full coverage of the grout, as determined by the Engineer, pumping of the grout will be required.

The grout shall be placed continuously. Delivery, mixing and placement shall proceed such that there will not be an interruption of more than 15 minutes duration in the placing of the grout over a single girder.

3.0 Finishing and Curing.
The exposed top surface of the grout shall be shall be struck off flush with the top of the deck and finished with a float. The surface shall be given a final finish by brushing with a bristle brush. The brush shall be drawn across the grout at right angles to the centerline of the roadway.

The exposed surfaces of the grout shall be wet cure for a minimum of 3 days or as directed by the Manufacturer to achieve the required design strength. The method of wet curing shall be in accordance with the DOT specifications.

Immediately after removal of forms, the exposed surfaces shall be finished in accordance with the DOT specifications except that grout cleaning and a rubbed finish is not required.

4.0 Application of Loads.
Vehicles, equipment and materials will not be permitted on the bridge until the grout has achieved a minimum compressive strength of 40 MPa.

10. Final pour for integral/semi-integral backwalls (if applicable)

If integral or semi-integral backwalls are used, the final pour will typically be done after the deck panels are in place and the grout for the connections and haunches have cured.

11. Installation of barrier rails/curbs and expansion joints (if applicable)

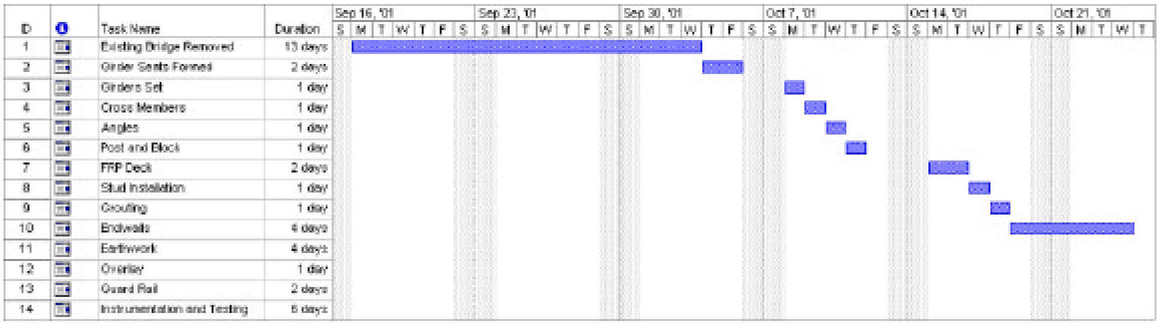
After the grout has achieved a minimum compressive strength of 40 Mpa, the barrier rail/curbs and expansion joints can be installed.

12. Installation of overlay (asphalt assumed)

The deck will be shipped to the site with an epoxy non-skid surface. Prior to applying the tack coat and overlay, a high pressure water blast (preferably using a degreaser) will be required by the contractor in the field prior to the application of the wearing surface to remove any contaminants. Allow to completely dry before applying tack coat and asphalt.

The type of overlay is the owner's choice. If another type of overlay is desired, such as polymer concrete or micro silica modified concrete, the epoxy grit will be eliminated and the surface will be heavily sanded prior to being shipped to the job site. A light sandblast will then be required at the site after the deck is in place, and after cleaning the surface, a primer will be applied to the deck surface prior to the overlay installation. For overlays other than asphalt, a screed application is highly recommended.

Appendix C – Timeline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Sep 30, '01
Oct 7, '01
Oct 14, '01
Oct 21, '01
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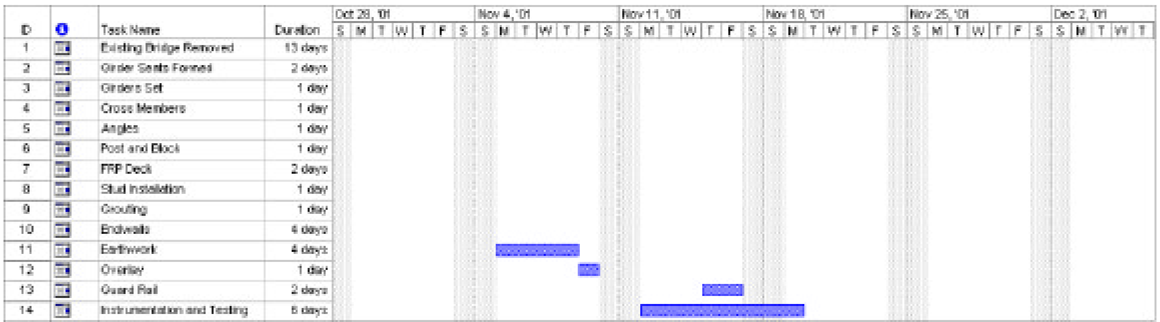
2 Girder Seats Formed 2 days
3 Girders Set 1 day
4 Cross Members 1 day
5 Angles 1 day
6 Post and Block 1 day
7 FRP Deck 2 days
8 Stud Installation 1 day
9 Grouting 1 day
10 Endwalls 4 days
11 Earthwork 4 days
12 Overlay 1 day
13 Guard Rail 2 days
14 Instrumentation and Testing 6 days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Task Name
Duration
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Nov 11, '01
Nov 18, '01
Nov 25, '01
Dec 2, '01
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2 Girder Seats Formed 2 days
3 Girders Set 1 day
4 Cross Members 1 day
5 Angles 1 day
6 Post and Block 1 day
7 FRP Deck 2 days
8 Stud Installation 1 day
9 Grouting 1 day
10 Endwalls 4 days
11 Earthwork 4 days
12 Overlay 1 day
13 Guard Rail 2 days
14 Instrumentation and Testing 6 days