

Fiber Reinforced Polymer (FRP) Composite Bridges in West Virginia



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EXECUTIVE SUMMARY

Starting in 1996, the West Virginia Department of Transportation, Division of Highways (WVDOT-DOH) began a program to utilize Fiber Reinforced Polymer (FRP) materials for bridge construction and rehabilitation. This work included the use of FRP deck systems in lieu of conventional concrete or steel decks, FRP rebar in place of steel, FRP wraps to repair deteriorated concrete and FRP to strengthen timber bridge components. Of the 25 FRP implementations on WVDOT-DOH bridges, 92% were completed between 1996 and 2004, thus providing over a decade of in-service data. This booklet provides a summary of how FRP was implemented and evaluates their performance using WVDOT inspection reports.

FRP bridge decks are factory manufactured panels and are assembled in the field to form bridge decks. The panels were made via pultrusion, infusion or hand lay-up. The 10 pultruded and infused decks in WV are still in service and all are in good condition with no major problems or maintenance items reported. Two bridge decks made via hand lay-up were replaced with concrete and steel decks after 9 years in service. With the exception of the hand lay-up designs, the FRP bridge decks are performing very well.

Wearing surfaces composed of either polymer concrete or asphalt were installed on all of the FRP bridge decks to prevent damage to the FRP, provide UV protection and to enhance traction for vehicles. The wearing surfaces have more issues, with 40% in good condition, 40% in fair condition and 20% in poor condition. Transverse cracking of the wearing surface is the typical complaint, which has been a lesson learned from these early implementation of FRP bridge decks. These decks allow for more movement directly under wheel loads, and the panel joints tend to create stress concentrations that can form hairline cracks in the wearing surface. However, as FRP is not corroded by water, these cracks do not typically pose any long term serviceability problems; in fact, cracks were noted in some bridges shortly after construction but have not changed significantly since. The bridges with poor wearing surfaces have larger cracks and delaminations, wherein the wearing surface breaks up and separates from the deck. This has occurred with both asphalt and polymer concrete wearing surfaces with different FRP decks. The wearing surface issues have been mostly solved in more recent designs due to better design details, appropriate material selection and construction methods.

FRP rebar was utilized in 6 bridges in WV between 1996 and 2001 for both the substructure and deck. When conventional steel rebar corrodes, it expands and fractures the concrete around the rebar. FRP rebar will not corrode, which makes it very advantageous in WV where deicing salt is used extensively. Three of the decks are rated as being in good condition, while the other 3 are rated as satisfactory. The 3 satisfactory bridges are on a 2.3 mile section of Cabin Creek Road, which is a section of the Coal Resource Transportation System. This allows trucks up to 60 tons to cross these bridges while they were designed for 45 ton trucks. Each of the three bridges is a similar design consisting of prestressed concrete box girders with a concrete deck

reinforced with FRP rebar. Each of these three bridges has similar inspection notes, including cracks up to 1/16" wide. On the North Acme Bridge, inspectors suggest the FRP rebar may be in distress, but do not make this conclusion on the other bridges where they are unaware of the presence of FRP rebar. This illustrates that the inspectors in the field have a lack of understanding of FRP and may misattribute problems to the FRP decks. Overall, these 6 bridges indicate that FRP rebar is performing very well in WV.

A total of 5 bridge rehabilitation projects used FRP wraps to repair concrete piers or abutments between 1998 and 2014. The FRP wraps bond to the concrete surface to compensate for strength lost due to deterioration, corrosion or fire damage. The use of FRP wraps allows the rehabilitation of the existing concrete, thus it is an economic repair as substructure replacement generally involves replacing the entire bridge. For all applications, no issues are reported with the FRP wrap, and only one instance of the paint over the wrap starting to peel off. These repairs have saved the WVDOT thousands of dollars compared to conventional repairs.

The Blennerhassett Island Bridge carrying US Route 50 over the Ohio River features a FRP inspection walkway and electrical conduit running underneath the bridge. Inspectors have noted the walkway is more flexible, but seems to keep trespassers away. There is some minor UV damage on access points that get direct sunlight. The Barrackville Covered Bridge was rehabilitated in 1999 using embedded FRP rods to reinforce the existing wood truss. The embedded FRP provides additional strength without compromising the look of the bridge. The Robert Beech Bridge was designed to include FRP reinforcement in the glulam arch, which is in good condition. The Laurel Lick bridge includes FRP stringers and FRP support piles, which are performing well. During rehabilitation of the Katy Truss Bridge in 2001, a diagonal truss member was replaced with two FRP angles and no issues have been reported with this member.

In addition to the WVDOT-DOH bridge projects detailed herein, there have been several other applications of FRP in WV infrastructure. The South Branch Valley Railroad has utilized FRP wraps to repair over 50 timber piles and several bridge stringers on 100+ year old railroad bridges. A section of WV Route 9 near Martinsburg was constructed with the concrete pavement continuously reinforced with FRP rebar, the first such application in the country. FRP dowel bars have been used during the construction of Corridor H near Elkins, WV and rehabilitation of concrete pavement along University Avenue in Morgantown, WV. Finally, FRP and concrete rehabilitation of the East Lynn Lake Campground Bridge was awarded the US Army Corp of Engineers Innovation of the Year Award in 2014 due to the rapid installation of the low cost repair.

Overall, the FRP bridges in WV are performing quite well. There have been some lessons learned regarding FRP deck types and wearing surface issues which are typical for any new material. Although this is a limited dataset, it does show that when properly engineered and constructed, FRP materials do perform well in demanding highway applications.

Hardcore Composites Deck



Deck System

The Boy Scout Camp Bridge is located in Raleigh County (District 10) at Latitude, Longitude 37.71251, -81.14951 and was originally built in 2001 by District 10 of the WVDOT-DOH. The single span bridge has an overall length of 33.1 feet with a maximum span length of 29.9 feet with no skew. The bridge is 25.8 feet wide and carries 500 vehicles per day across 2 lanes at medium to low speed along a paved road.

INSPECTION HISTORY

Most Recent Inspection
12/16/2014

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
92.0

WVDOH Inspection Appraisal Ratings

Deck	Superstructure	Substructure
Very Good	Satisfactory	Satisfactory

Current FRP Condition: The deck is in good condition. No loose panels or anchor clips were discovered and no leakage was noted along the panel joints.

The wearing surface is in place and provides a smooth ride. Slight transverse cracking exists along both ends of the deck.

Applicable Maintenance Issues: None



TYPICAL TRANSVERSE CRACKING

STRUCTURE DETAILS

Abutments: Reinforced concrete full height abutments on spread footings

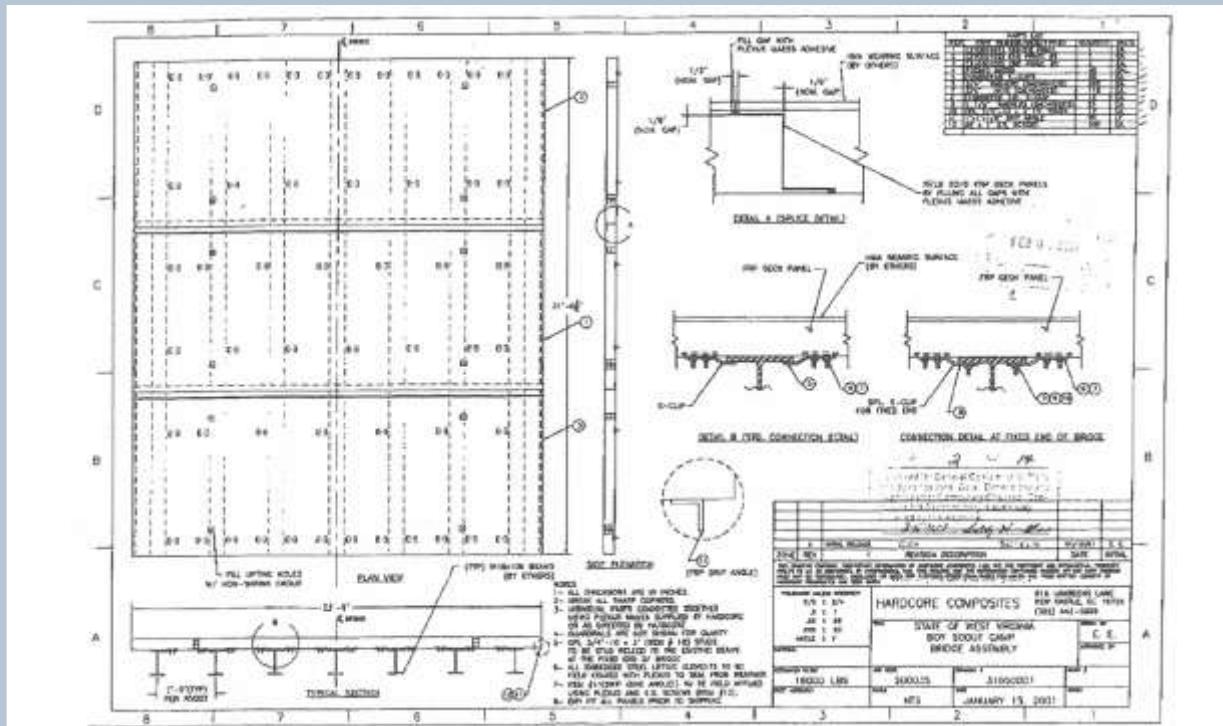
Superstructure: 7 W18x106 beams at 3'-9" spacing

Deck: 8" Hardcore Composites Deck

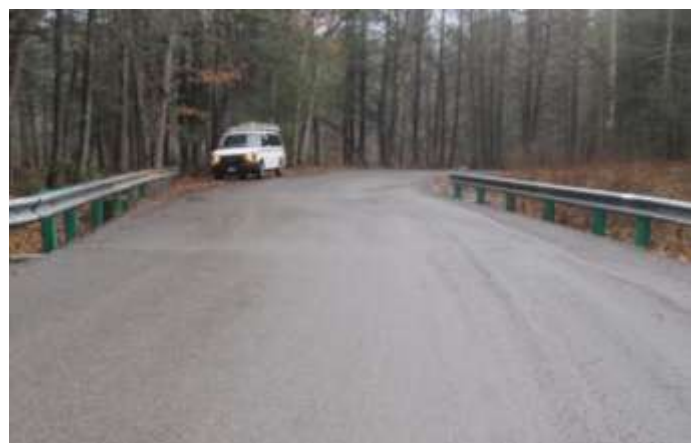
Deck-to-Stringer Attachment: Plexus MA55 adhesive and Z clips (2 bolt)

Wearing Surface: 3.5" asphalt

Bridge Assembly Plans



UNDERSIDE OF DECK



END VIEW OF BRIDGE

Bedford Reinforced Plastics Prodeck 4



Deck System

The Goat Farm Bridge is located in Jackson County (District 3) at Latitude, Longitude 38.99921, -81.58049 and was originally built in 2004 by Alan Stone. The single span bridge has an overall length of 42.3 feet with a maximum span length of 39 feet with no skew. The bridge is 15 feet wide and carries 10 vehicles per day at low speed along a 1 lane gravel road.

INSPECTION HISTORY

Most Recent Inspection
4/16/2014

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
86.8

WVDOH Inspection Appraisal Ratings

Deck	Superstructure	Substructure
Very Good	Very Good	Very Good

Narrative Rating: The deck and wearing surface are still in good condition and with no visible deficiencies.

Applicable Maintenance Issues: In 2010, state forces fastened the loose Z-clips, reinstalled the neoprene pads, and welded a keeper angle to hold the pads.



Z-CLIPS ATTACHING DECK TO BEAMS

STRUCTURE DETAILS

Abutments: Reinforced concrete stub on pilings (Abutment 1) and on original cut stone (Abutment 2)

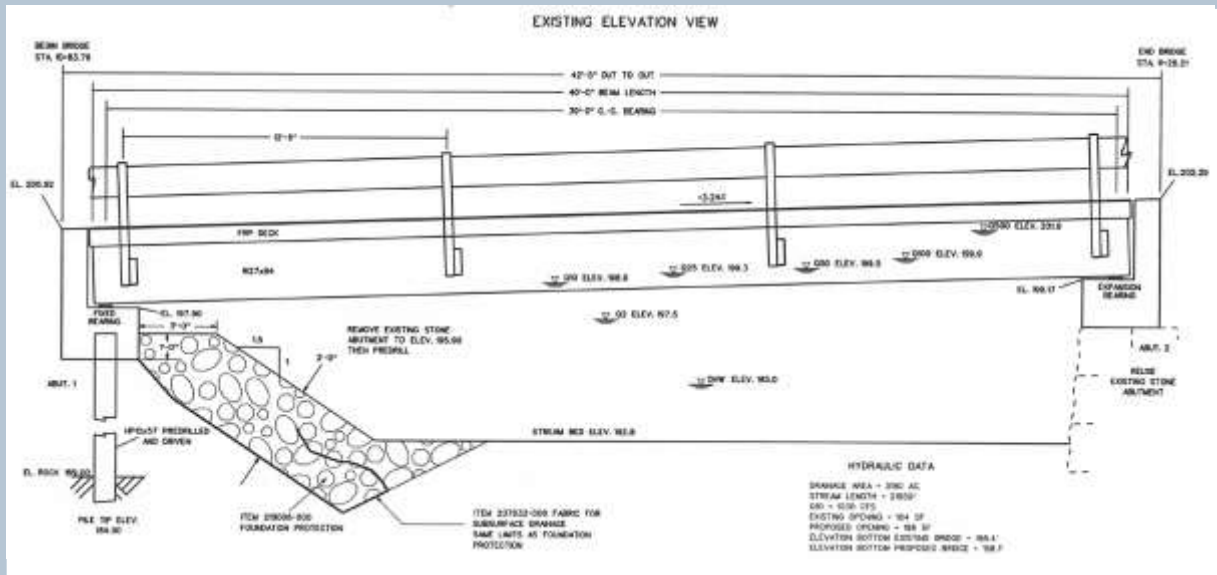
Superstructure: 5 W27x84 beams at 3'-4" spacing

Deck: 4" Bedford Reinforced Plastics Prodeck 4

Deck-to-Stringer Attachment: Z-Clips (1 bolt)

Wearing Surface: 3/8" polymer concrete

Elevation View



PLACEMENT OF DECK PANEL



REINFORCING FIELD JOINT

HOWELL'S MILL

BARS: 06A261

Martin Marietta Duraspan Deck



Deck System

The Howell's Mill Bridge is located in Cabell County (District 2) at Latitude, Longitude 38.44253, -82.21986 and was originally built in 2003 by Turnman Construction. The two span bridge has an overall length of 237.5 feet with a maximum span length of 120 feet with no skew. The bridge is 32.5 feet wide and carries 3300 vehicles per day across 2 lanes on the rural paved road as speeds up to 50 mph.

INSPECTION HISTORY

Most Recent Inspection
5/10/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
79.9

WVDOH Inspection Appraisal Ratings

Deck	Superstructure	Substructure
Good	Good	Good

Current FRP Condition: The deck is in good condition. The decking appears to be loose in the area over the pier. The decking here rattles occasionally under live loads. The top of the deck is exposed in scattered locations due to missing asphalt. This break up is located at the junctures of the deck panels with the appearance of solar decomposition. The wearing surface is in fair condition. The wearing surface is cracking and breaking up over several of the joints exposing the top of the deck. During periods of hot weather the asphalt loses bond with the deck surface. This condition is visible in the form of large blisters.



BREAKUP OF DECK PANEL JOINT

Applicable Maintenance Issues: None

STRUCTURE DETAILS

Abutments: Reinforced concrete integral on piling (abutment 1), semi-integral on spread footings (Abutment 2) and reinforced concrete pier on spread footings

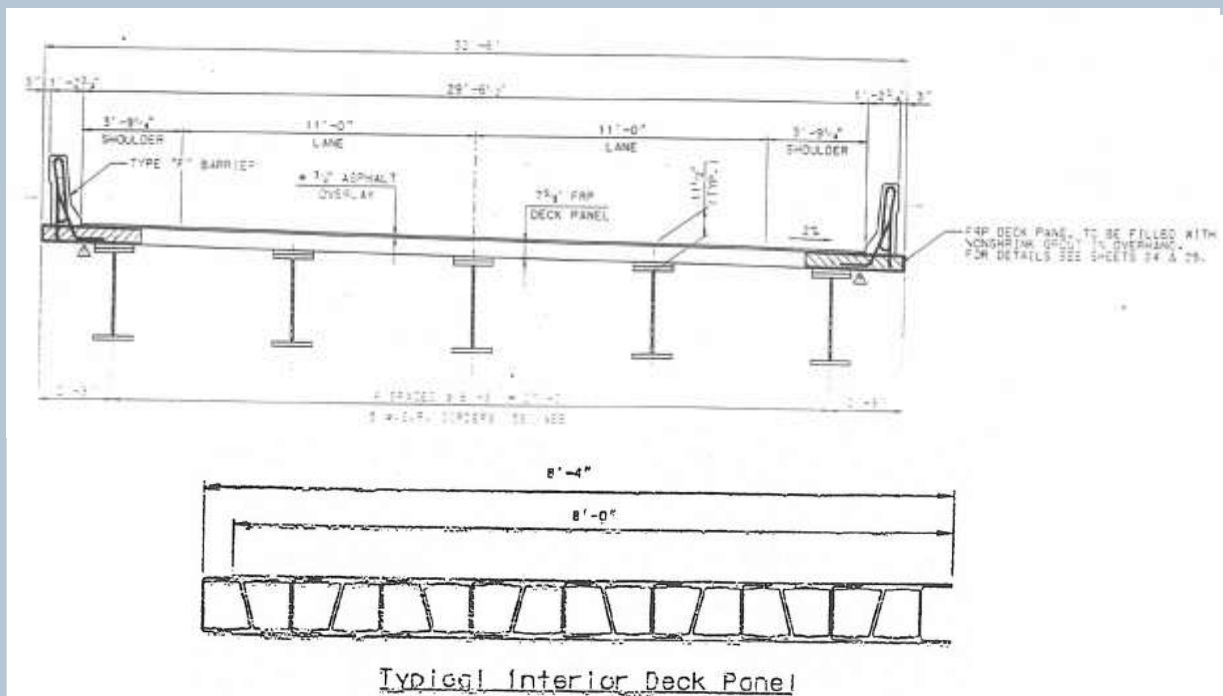
Superstructure: 5 welded plate girders with 38" web at 6'-9" spacing, continuous over pier

Deck: 7.625" Martin Marietta Duraspan deck

Deck-to-Stringer Attachment: unknown - Possible grout pocket?

Wearing Surface: 1" asphalt

Deck Section



BREAK UP OF WEARING SURFACE AND DETERIORATION
OF DECK PANEL JOINT REINFORCEMENT



BOTTOM OF DECK

Bedford Reinforced Plastics Prodeck 8



Deck System

The Kite Creek Bridge is located in Monroe County (District 9) at Latitude, Longitude 37.40052, -80.80095 and was originally built in 2004 by District 9 of the WVDOT-DOH. The single span bridge has an overall length of 34.6 feet with a maximum span length of 30.5 feet with no skew. The bridge is 24.1 feet wide and carries 500 vehicles per day across 2 lanes on the municipal paved road with a 25 mph speed limit.

INSPECTION HISTORY

Most Recent Inspection
5/16/2014

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
84.5

WVDOH Inspection Appraisal Ratings

Deck	Superstructure	Substructure
Very Good	Very Good	Very Good

Current FRP Condition: The deck is in good condition with no defects. The wearing surface is in fair condition with transverse open cracks spaced approximately 18" across the entire deck with map cracking on the abutment #2 end of the structure. There is an area near the center of the roadway with missing asphalt and map cracking at abutment #2, 2'-0" in length, 6'-0" in width and averaging 2 inches in depth

Applicable Maintenance Issues: None



TRANSVERSE CRACKS IN WEARING SURFACE

STRUCTURE DETAILS

Abutments: Reinforced concrete stub abutments on spread footings

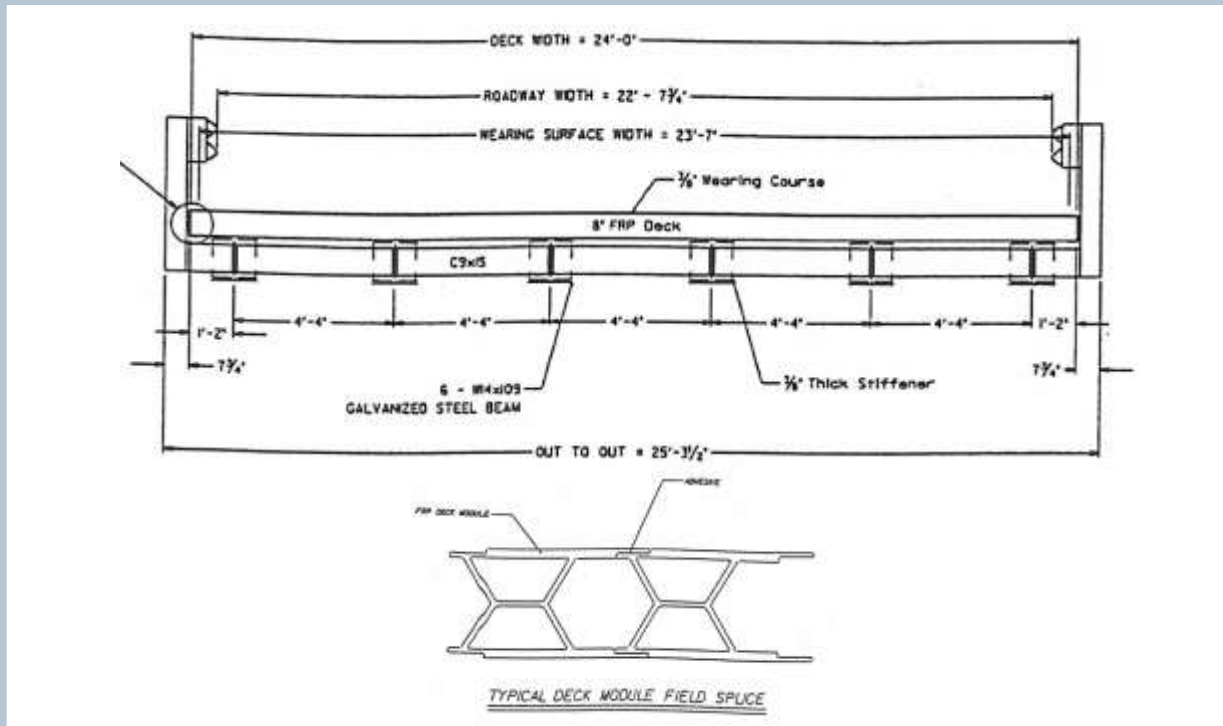
Superstructure: 6 W14x109 beams at 4'-4" spacing

Deck: 8" Bedford Reinforced Plastics Prodeck 8

Deck-to-Stringer Attachment: Z clips (1 bolt)

Wearing Surface: 1.5" asphalt

Typical Deck Section



UNDERSIDE OF DECK



MISSING ASPHALT AT ABUTMENT 2

Bedford Reinforced Plastics Prodeck 8



Deck System

The La Chein Bridge is located in Monroe County (District 9) at Latitude, Longitude 37.39903, -80.80359 and was originally built in 2003 by the WVDOT-DOH. The single span bridge has an overall length of 42.8 feet with a maximum span length of 38.3 feet with 30 degrees skew. The bridge is 24 feet wide and carries 30 vehicles per day across 2 lanes on the paved low speed road.

INSPECTION HISTORY

Most Recent Inspection
5/3/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
99.0

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Very Good	Good	Good

Current FRP Condition: The deck is in good condition with no significant defects. The wearing surface is in fair condition with several transverse cracks.

Applicable Maintenance Issues: Asphalt wearing surface added in 2003 by contract.



TRANSVERSE CRACKING IN WEARING SURFACE

STRUCTURE DETAILS

Abutments: Reinforced concrete semi-integral abutments on solid rock

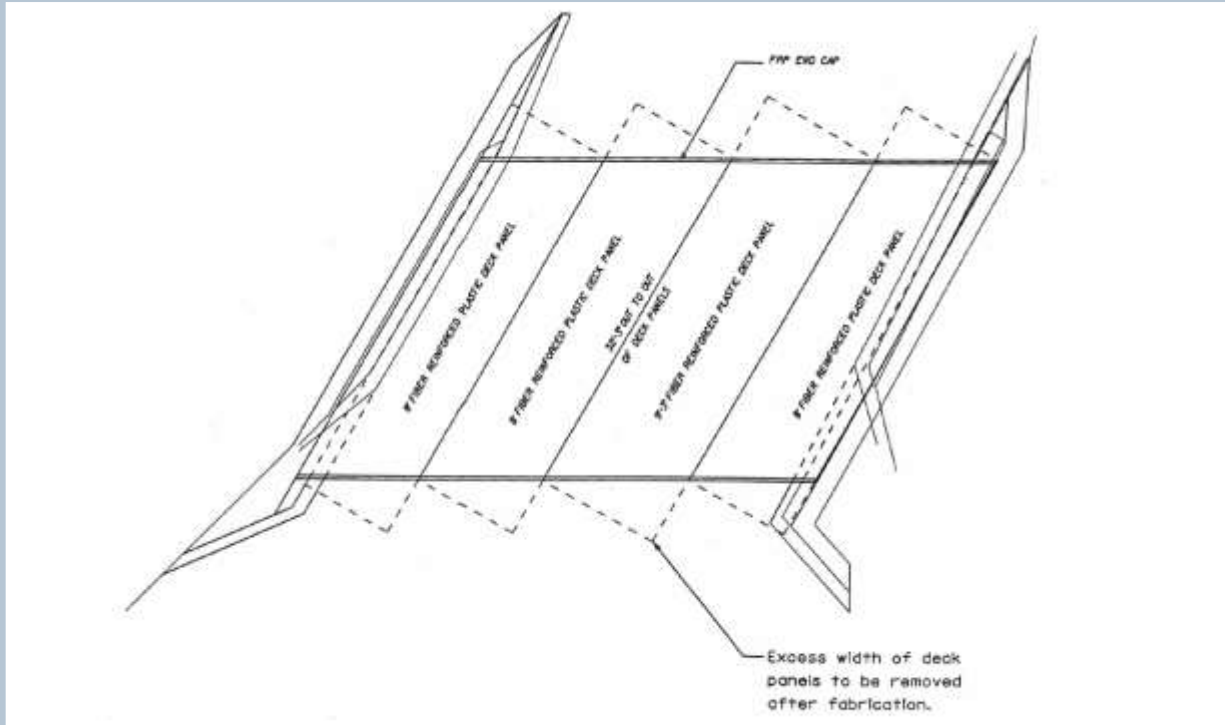
Superstructure: 6 W18x86 beams at 4'-4" spacing

Deck: 8" Bedford Reinforced Plastics Prodeck 8

Deck-to-Stringer Attachment: Adhesive bonding

Wearing Surface: 3" asphalt

Deck Plan View



UNDERSIDE OF DECK



END VIEW

MARKET STREET

BARS: 35A136

Creative Pultrusions Superdeck on Bridge, Approach Slabs and Sidewalk.



Deck System

The Market Street Bridge is located in Ohio County (District 6) at Latitude, Longitude 40.062542, -80.722052 and was originally built in 2001 by Jarvis Downing and EMCH (JD&E). The use of FRP allowed for a lower deadweight and the elimination of a pier from the previous bridge. The single span bridge has an overall length of 180.5 feet with a maximum span length of 177 feet with no skew. The bridge is 56 feet wide and carries 3000 vehicles per day across 3 lanes on the municipal paved road at speeds up to 40 mph.

INSPECTION HISTORY

Most Recent Inspection
10/14/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
88.2

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Good	Good	Good

Current FRP Condition: The deck is still in good condition. There is efflorescence and moisture at the joints. The wearing surface is now in poor condition. The surface continues to display cracks, peeling granite, patchwork, and potholes exposing the FRP deck. This allows moisture to pass on to the superstructure. The sidewalks are now in fair condition. The polyurethane concrete with granite chips coating continues to display an increase in the cracks and deterioration the full length of the upstream and downstream walkways. The fiber glass joint material now displays poor adhesion and has lifted at random locations.



DELAMINATIONS IN WEARING SURFACE

Applicable Maintenance Issues: None

Abutments: Reinforced concrete integral stub abutments on piles
Superstructure: 7 welded plate girders with 78" deep web and 24" wide flanges at 8'-6" spacing
Deck: 8" Creative Pultrusions Superdeck on bridge, 4'-3" of approach slabs and as sidewalk.
Deck-to-Stringer Attachment: Grout pockets
Wearing Surface: 1/2" polyurethane and granite chips

[illegible]

Hardcore Composites Deck and 1-1/2" FRP Decking on Sidewalk



Deck System

The Montrose Bridge is located in Randolph County (District 8) at Latitude, Longitude 39.06799, -79.81114 and was originally built in 2001 by the WVDOT-DOH. The single span bridge has an overall length of 40.7 feet with a maximum span length of 37 feet with no skew. The bridge is 27.5 feet wide and carries 600 vehicles per day across 2 lanes on the rural paved road at speeds up to 50 mph.

INSPECTION HISTORY

Most Recent Inspection
10/10/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
94.5

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Good	Good	Good

Current FRP Condition: The deck is in good condition. There were no deck clips broken or loose but there is deck movement under live load. The deck clips at Abutment 2 are bent due to over tightening. The wearing surface is in poor condition, due to cracks at all deck panel joints, with minor advancement since 2011. There is some minor leakage visible near Abutment 1. There are short longitudinal cracks at both abutments. The cracks are $\pm 1/16''$ to $5/16''$ wide. The sidewalk is in good condition.

Applicable Maintenance Issues: The original 3/8" thick epoxy wearing surface distintegrated following a very short service life. A new 2.25" (average) asphalt surface was applied in 2002.



WEARING SURFACE CRACK

STRUCTURE DETAILS

Abutments: Full height reinforced concrete abutments on spread footings

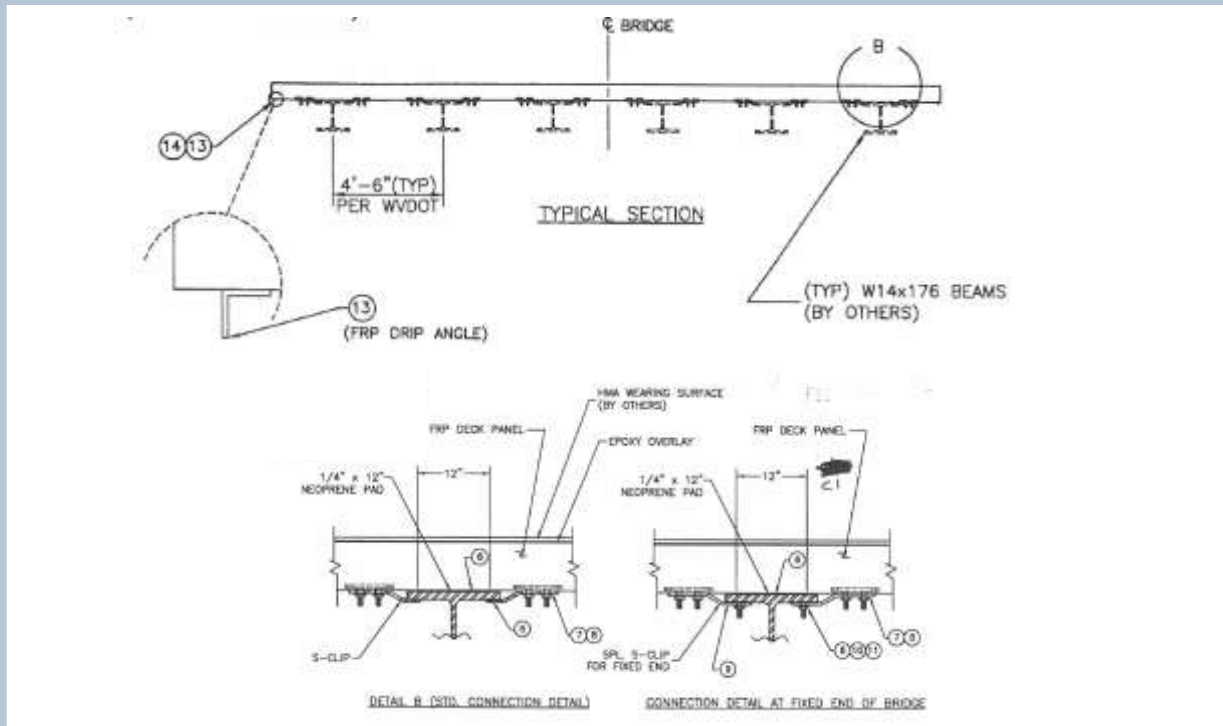
Superstructure: 5 W14x176 beams at 4'-6" spacing

Deck: 8" Hardcore Composites Deck on bridge and 1-1/2" FRP decking on separate sidewalk

Deck-to-Stringer Attachment: Z Clips (2 bolts)

Wearing Surface: 2.25" asphalt

Elevation View



WEARING SURFACE CONDITION



FRP SIDEWALK ADJACENT TO BRIDGE

WICKWIRE RUN

BARS: 46A077

Creative Pultrusions Superdeck



Deck System

The Wickwire Run Bridge is located in Taylor County (District 4) at Latitude, Longitude 39.38112, -79.97467 and was originally built in 1997 by the WVDOT-DOH. The single span bridge has an overall length of 34.5 feet with a maximum span length of 30 feet with no skew. The bridge is 21.8 feet wide and carries 250 vehicles per day across 2 lanes along a paved road.

INSPECTION HISTORY

Most Recent Inspection
10/1/2013

Design Load
HS-25

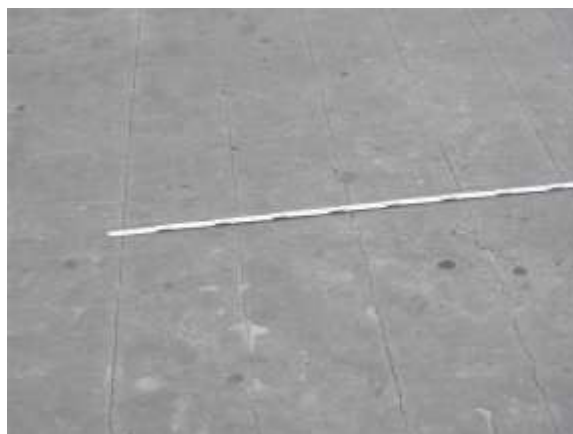
Unofficial FHWA Sufficiency Rating
83.0

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Good	Very Good	Very Good

Current FRP Condition: The deck is in good condition. A few of the fasteners are loose. The wearing surface is in fair condition. Transverse cracks have developed in the wearing surface at the joints between the four pre-constructed deck panels. Corresponding cracks have developed in the concrete curbs. Cracks are also present over the joint between individual FRP planks and delaminations and map cracking exist. A few areas of missing wearing surface are also present. Water tends to stand on the deck near Abutment 2.

Applicable Maintenance Issues: None



CRACKS IN WEARING SURFACE

STRUCTURE DETAILS

Abutments: Full-height concrete abutments

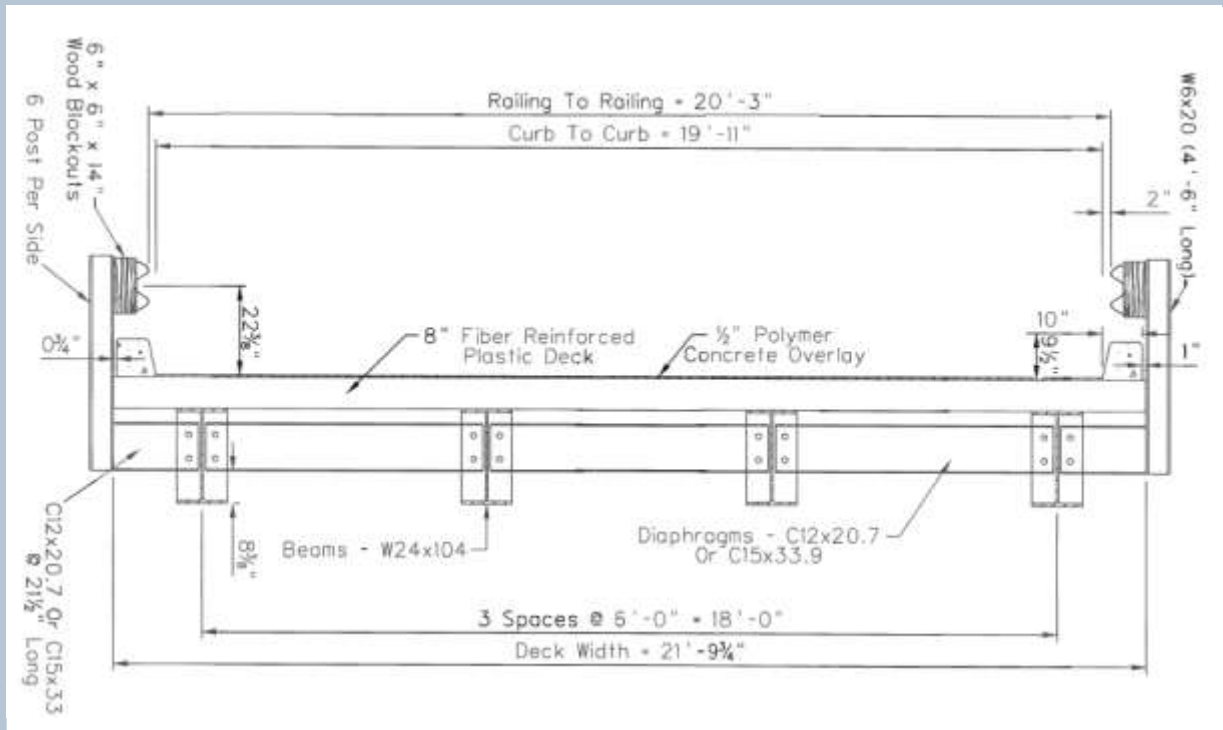
Superstructure: 4 W24x104 beams at 6'-0" spacing

Deck: 8" Creative Pultrusions Superdeck

Deck-to-Stringer Attachment: Blind fasteners and Pliogrip

Wearing Surface: 1/2" polymer concrete

Inspection Sketch



DECK INSTALLATION



GALVANIZED STEEL BLIND BOLT (POP RIVET)

DAN'S RUN SLAB

GFRP Reinforced Concrete Deck and Substructure



The Dan's Run Slab Bridge is located in Mineral County (District 5) at Latitude, Longitude 39.558302, -78.715973 and was originally built in 2000 by the WVDOT-DOH. The single span bridge has an overall length of 14 feet with a maximum span length of 12 feet with no skew. The deck is 24 feet wide and carries 150 vehicles per day across 2 lanes on the gravel road.

Reinforcing Bar

INSPECTION HISTORY

Most Recent Inspection
8/30/2010

Design Load
HS-25

The Dan's Run Slab Bridge is under 20 feet, and thus not subject to the NBI inspection standards. The condition reported herein is based on the comments from the District 5 Bridge Engineer.

Current Deck Condition:

The bottom of the deck exhibits a few short lateral cracks with efflorescence

Applicable Maintenance Issues:

None



TOP OF SLAB

STRUCTURE DETAILS

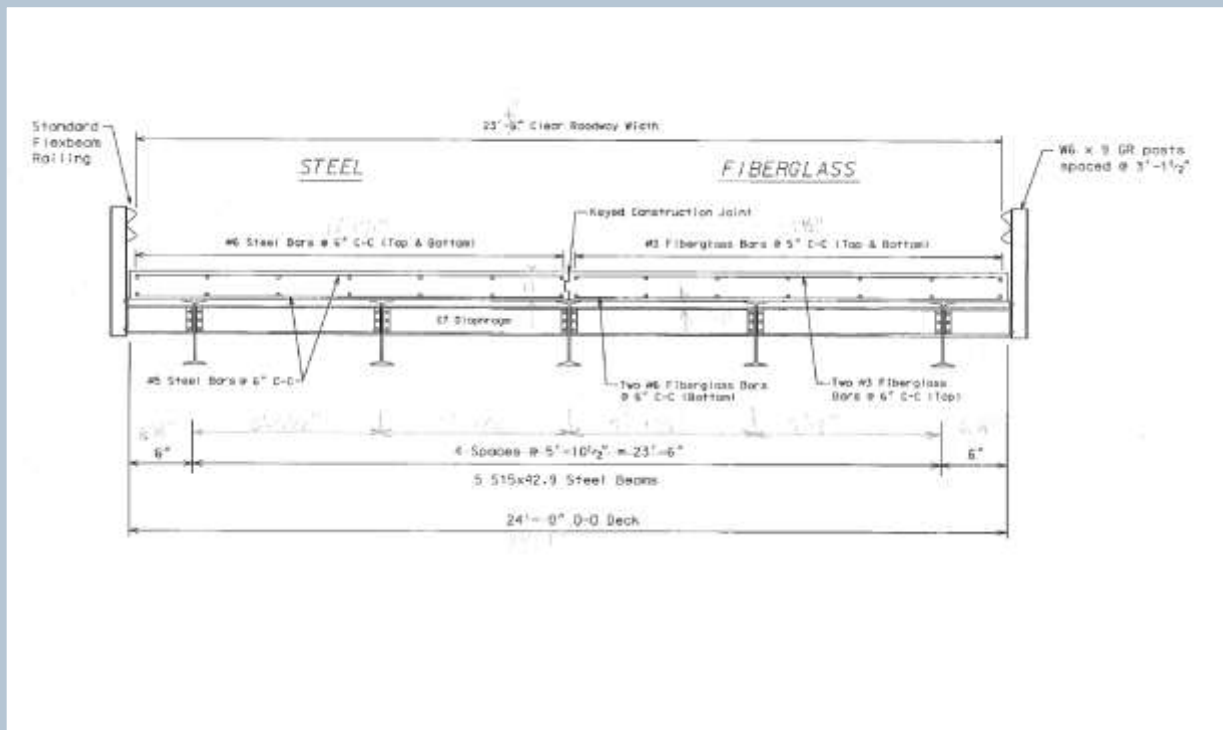
Abutments: Cast in place concrete slab

Superstructure: 5 S15x42.9 beams at 5'-10.5" spacing

Deck: 18" cast-in-place concrete, ½ reinforced with steel and ½ reinforced with GFRP rebar

Wearing Surface: none

Deck Cross Section



PERSPECTIVE VIEW

Glass C-Bar Reinforced Concrete Deck and Abutment



Reinforcing Bar

The Martha Queen's Bridge is located in Lewis County (District 7) at Latitude, Longitude 39.07852, -80.47738 and was originally built in 2001 by the WVDOT-DOH. The single span bridge has an overall length of 49.5 feet with a maximum span length of 48 feet with 30 degrees skew. The deck is 30.1 feet wide and carries 900 vehicles per day across 2 lanes on the rural road at speeds up to 50 mph.

INSPECTION HISTORY

Most Recent Inspection
8/12/2011

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
92.8

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Good	Very Good	Very Good

Current Deck Condition:

No report is available.

Applicable Maintenance Issues:

None



GFRP REINFORCEMENT IN ABUTMENTS

STRUCTURE DETAILS

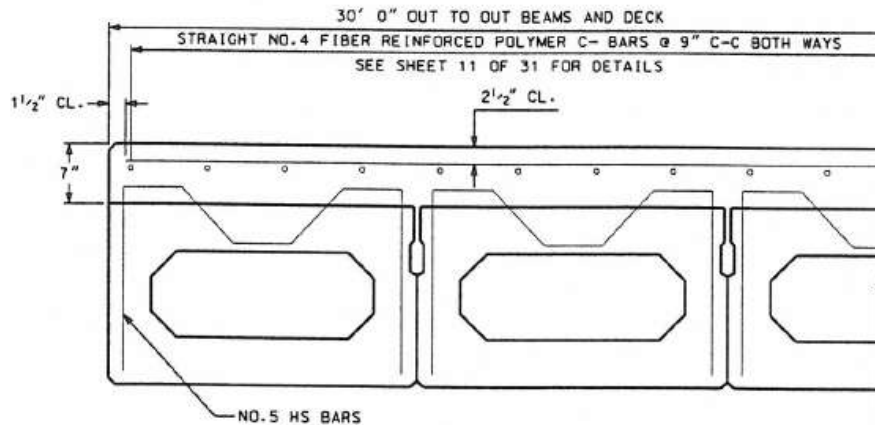
Abutments: Reinforced concrete stub abutments with GFRP rebar

Superstructure: 10 concrete box beams, 3' wide x 21" tall installed flush to each other

Deck: 7" cast-in-place concrete with GFRP rebar

Wearing Surface: none

Bridge Deck Cross Section



BRIDGE DECK CROSS SECTION



END VIEW



CLOSE UP OF REBAR IN ABUTMENT

International Grating and Glass C-Bar Reinforced Concrete Deck



Reinforcing Bar

The McKinleyville Bridge is located in Brooke County (District 6) at Latitude, Longitude 40.24392, -80.59623 and was originally built in 1996 by Orders Construction Company. The three span bridge has an overall length of 180 feet with a maximum span length of 73 feet with no skew. The deck is 29.5 feet wide and carries 150 vehicles per day across 2 lanes along the paved road.

INSPECTION HISTORY

Most Recent Inspection
9/5/2014

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
98.9

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Good	Good	Very Good

Current Deck Condition: The deck is in good condition. The underside continues to display numerous hairline transverse cracks with efflorescence stains in each span. There are small random isolated minor spalls in the deck haunches. The deck edge has random hairline cracks, there are transverse cracks with efflorescence in the overhangs. The textured concrete surface remains in good condition. There are still numerous hairline to 1/16" wide transverse, longitudinal and random cracks in each span. There are now small shallow edge spalls at the deck ends.



CRACKS IN THE WEARING SURFACE

Applicable Maintenance Issues: None

STRUCTURE DETAILS

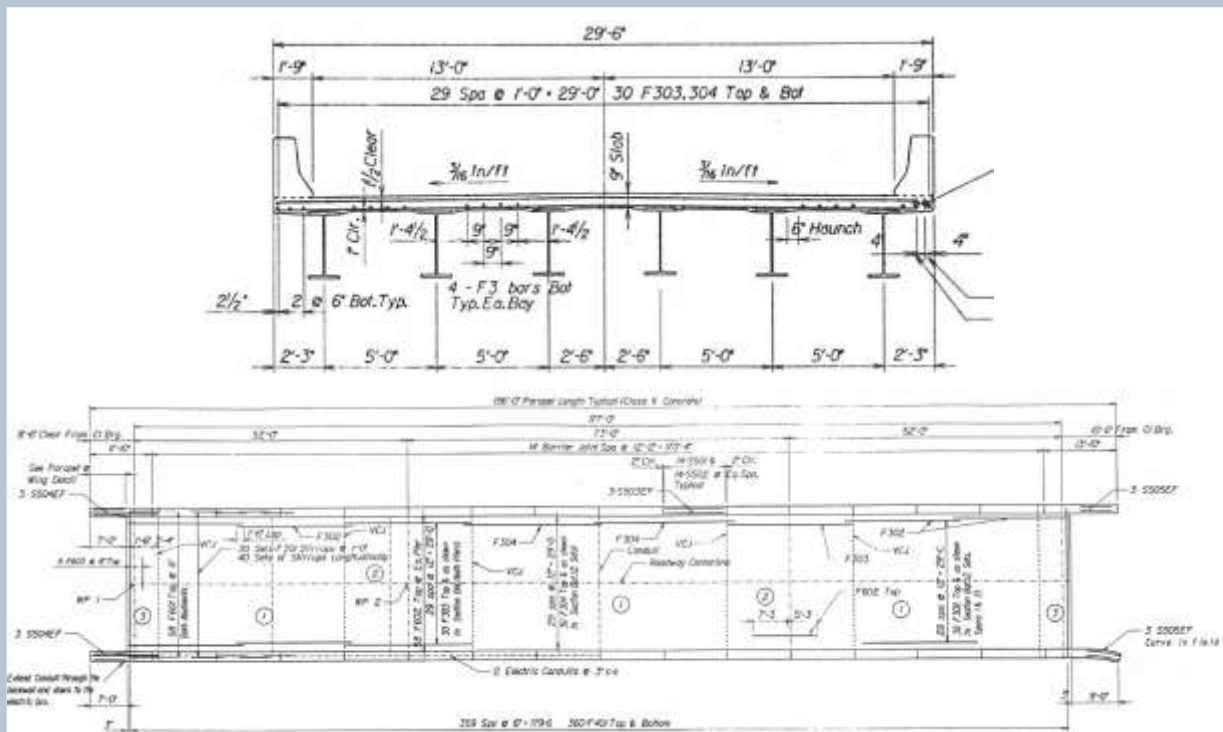
Abutments: Full height reinforced concrete integral abutments

Superstructure: 6 W33x130 beams at 5'-0" spacing

Deck: 9" cast-in-place concrete with sand coated GFRP rebar

Wearing Surface: none

Plans



GFRP REINFORCEMENT IN DECK WITH STEEL SHEAR STUDS



UNDERSIDE OF DECK WITH CRACKS/EFFLORESCENCE

NORTH ACME

BARS: 20A796

Hughes Brothers GFRP Reinforced Concrete Deck



Reinforcing Bar

The North Acme Bridge is located in Kanawha County (District 1) at Latitude, Longitude 38.039522, -81.456284 and was originally built in 1940, and rebuilt in 2001 by WVDOT-DOH with FRP rebar. The single span bridge has an overall length of 35.3 feet with a maximum span length of 30 feet with 30 degrees skew. The deck is 24 feet wide and carries 650 vehicles per day across 2 lanes on the rural paved roads at speeds up to 50 mph.

INSPECTION HISTORY

Most Recent Inspection
10/23/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
86.0

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Satisfactory	Very Good	Satisfactory

Current Deck Condition: The deck remains in fair condition. The top surface is slightly uneven due to the finishing technique. Hairline to 1/16" map cracking, with some water staining, is noted throughout the entire deck surface. The 2007 inspection observed "light cracking", while the 2009 inspection observed "an array of longitudinal hairline to 1/16" cracking in numerous areas". The inspectors believe the GFRP reinforced concrete deck is showing signs of advancing distress and should be dealt with accordingly. However, a relatively smooth ride is provided across the structure.



CRACKING IN DECK

Applicable Maintenance Issues: None

STRUCTURE DETAILS

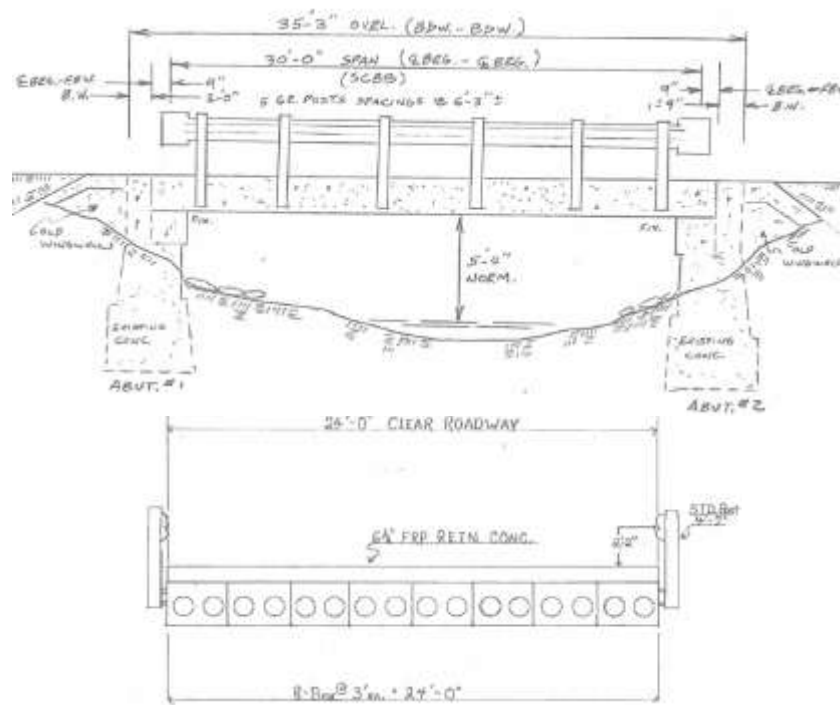
Abutments: Full height reinforced concrete abutments with flared wingwalls

Superstructure: 8 concrete box beams (3' wide) flush together

Deck: 6.5" cast-in-place concrete with GFRP rebar

Wearing Surface: none

Inspection Sketch



MAP CRACKING IN DECK



TOP OF DECK

NORTH KAYFORD

BARS: 20A773

Hughes Brothers GFRP Reinforced Concrete Deck



Reinforcing Bar

The North Kayford Bridge is located in Kanawha County (District 1) at Latitude, Longitude 38.02082, -81.45112 and was originally built in 1940 and rebuilt with FRP in 2000 by WVDOT-DOH District 1. The single span bridge has an overall length of 43 feet with a maximum span length of 36 feet with 45 degrees skew. The deck is 24.2 feet wide and carries 650 vehicles per day along the rural road at speeds up to 50 mph.

INSPECTION HISTORY

Most Recent Inspection
3/11/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
86.0

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Satisfactory	Very Good	Satisfactory

Current Deck Condition: The deck remains in fair condition, with hairline to 1/32" map cracking near Abutment One, longitudinal hairline to 1/32" cracking extending from the map cracking towards Abutment Two over Beam Four, a transverse/diagonal hairline crack over Beam Two at Abutment Two and exposed aggregate and a roughened deck surface in the wheel paths. A vertical hairline to 1/16" crack was also observed in the exterior upstream side just forward of the first guardrail post. Despite these deficiencies a relatively smooth ride is provided across the structure.



Applicable Maintenance Issues: None

MAP CRACKING IN DECK

STRUCTURE DETAILS

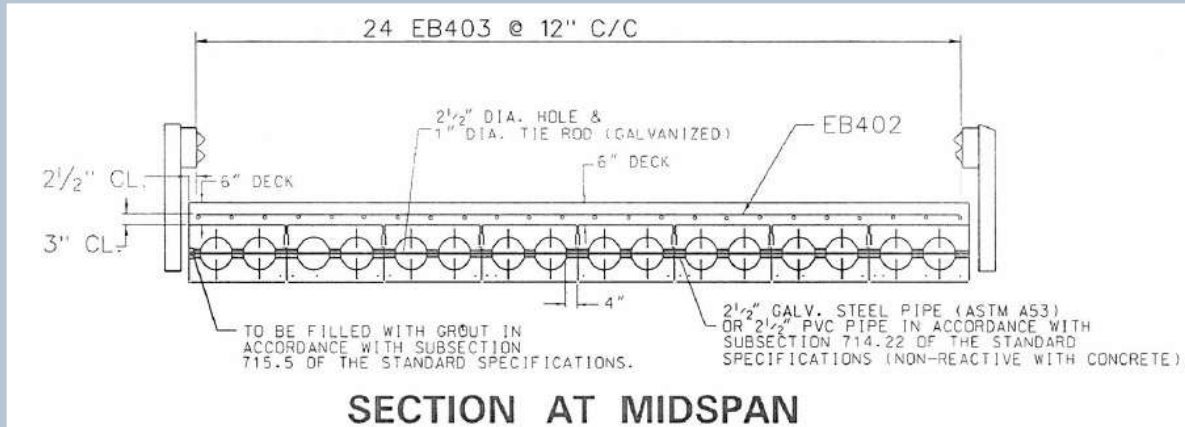
Abutments: Full height reinforced concrete abutments with reinforced concrete bridge seat and straight wingwalls

Superstructure: 8 concrete box beams (3' wide) flush together

Deck: 6" cast-in-place concrete with GFRP rebar

Wearing Surface: none

Plans



DECK SURFACE



HAIRLINE CRACKS IN DECK

SOUTH ACME

BARS: 20A780

Hughes Brothers GFRP Reinforced Concrete Deck



The South Acme Bridge is located in Kanawha County (District 1) at Latitude, Longitude 38.03307, -81.45403 and was originally built in 1940, and rebuilt in 2001 by WVDOT-DOH District 1 with FRP rebar. The single span bridge has an overall length of 34.4 feet with a maximum span length of 30 feet with 30 degrees skew. The deck is 24.1 feet wide and carries 650 vehicles per day across 2 lanes along the rural road at speeds up to 50 mph.

Reinforcing Bar

INSPECTION HISTORY

Most Recent Inspection
3/14/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
86.0

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Satisfactory	Very Good	Good

Current Deck Condition:

The deck remains in fair condition exhibiting the same map, diagonal, and longitudinal cracking as noted in 2009 and 2011 . Due to the staining between the beam undersides, we believe the 6" deck is leaking.

Applicable Maintenance Issues:

None



DECK CRACKING

STRUCTURE DETAILS

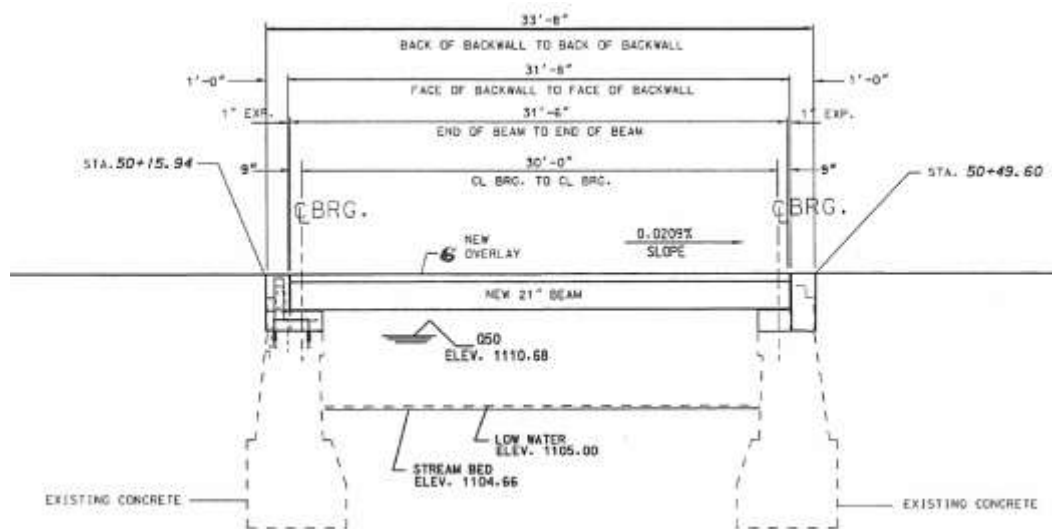
Abutments: Reinforced concrete full height abutments

Superstructure: 8 concrete box beams (3' wide) flush together

Deck: 6" cast-in-place concrete GFRP rebar

Wearing Surface: none

Construction Plans



GFRP REBAR IN DECK



CLOSE UP OF REBAR

CR 25 (POND CREEK)

BARS: 54A112

GFRP Wraps and GFRP Shells on Piers



Wrapping

The CR 25 (Pond Creek) Bridge is located in Wood County (District 3) at Latitude, Longitude 39.052513, -81.596819 and was originally built in 1967, with FRP installed in 1998 by Wiseman Construction and again in 2009. The three span bridge has an overall length of 156 feet with a maximum span length of 57.4 feet with 38 degrees skew. The deck is 40.7 feet wide and carries 7,000 vehicles per day across 2 lanes of Interstate 79 at speeds up to 70 mph.

INSPECTION HISTORY

Most Recent Inspection
2/19/2013

Design Load
HS-20 modified

Unofficial FHWA Sufficiency Rating
96.0

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Satisfactory	Good	Satisfactory

Current FRP Condition:

The FRP repairs remain in good condition.

Applicable Maintenance Issues: The columns in Pier 1 were encased in concrete in 1990 to repair damage due to a fire. In 1998, these columns were repaired with FRP wraps and shells to provide confinement to the concrete to address cracking in the original repair. Three of the columns were repaired again in 2008 following another fire that damaged the 1998 FRP repair.



COLUMNS WRAPPED WITH FRP

STRUCTURE DETAILS

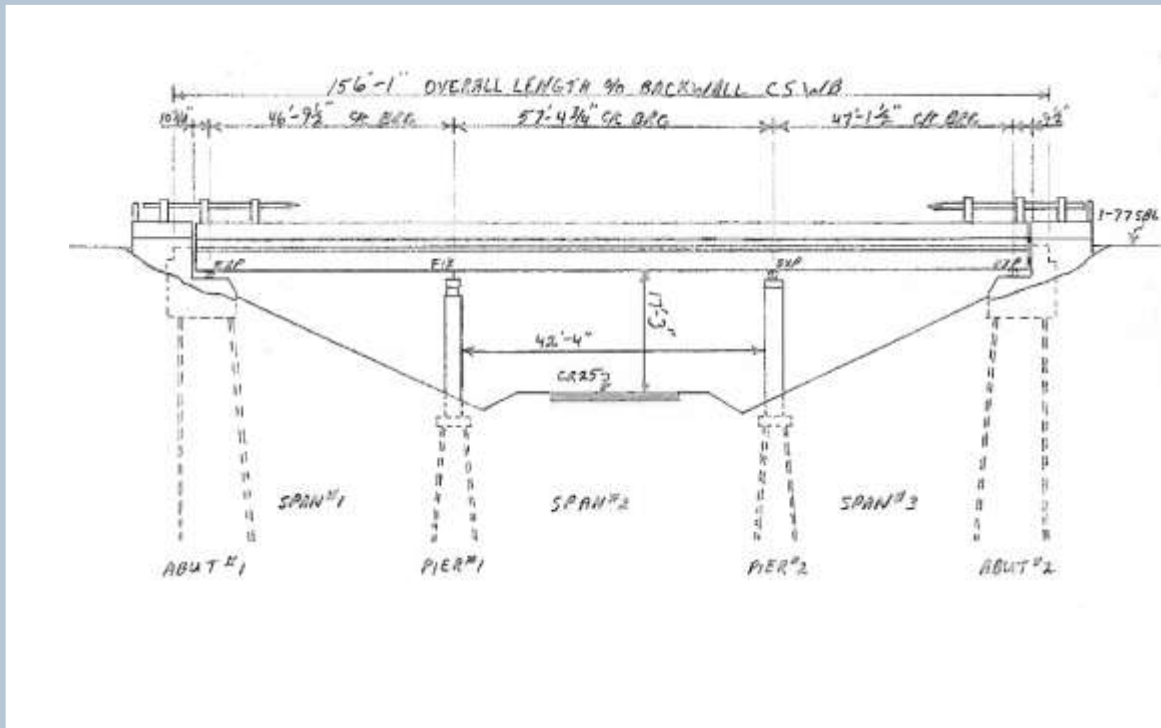
Abutments: 3' diameter reinforced concrete column piers with cantilever caps

Superstructure: 6 W33x118 beams at 6'-9.5" spacing

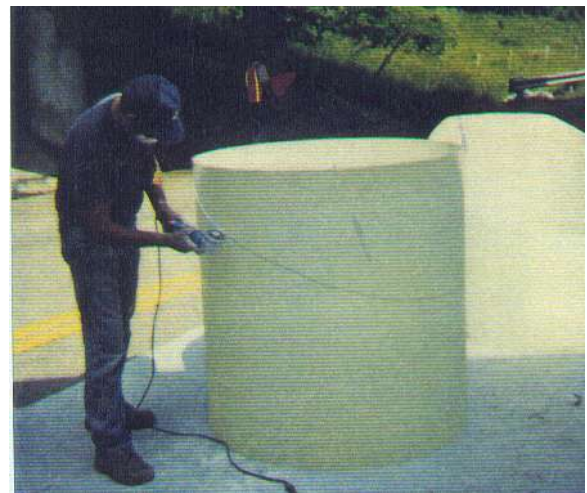
Deck: 7" Concrete Cast-in-Place

FRP wrap usage: Hexcel Fyfe GFRP wraps on 3 columns of Pier 1 and CC Myers SnapTite™ GFRP prefabricated jackets on 3 columns of Pier 1. Additional repairs in 2008 with Tyfo S Fiberwrap System.

Inspection Sketch



FRP WRAP INSTALLATION



FRP SHELLS PRIOR TO INSTALLATION

EAST STREET VIADUCT

BARS: 54A042

GFRP Wrap on Abutments, Deck Slab and Columns



Wrapping

The East Street Viaduct Bridge is located in Wood County (District 3) at Latitude, Longitude 39.260856, -81.545893 and was originally built in 1907, with FRP installed in 2001 by Al Johnson, Inc. The three span bridge has an overall length of 64.7 feet with a maximum span length of 23.3 feet with no skew. The deck carries 2'-6" of railroad balast and 10 sets of tracks over 15,100 vehicles per day along East Street.

INSPECTION HISTORY

Most Recent Inspection
12/5/2014

Current FRP Condition: The FRP wrap is still in good condition and there are no indications of any problems with the underlying concrete. The 3'-0" reinforced concrete top slab is still in fair condition. There were no apparent problems with the fill or tracks.

Applicable Maintenance Issues: In 2012, state forces painted fiberglass, touched up FRP, and made minor repairs to the FRP headwall over the southbound lane.



UNDERSIDE OF BRIDGE

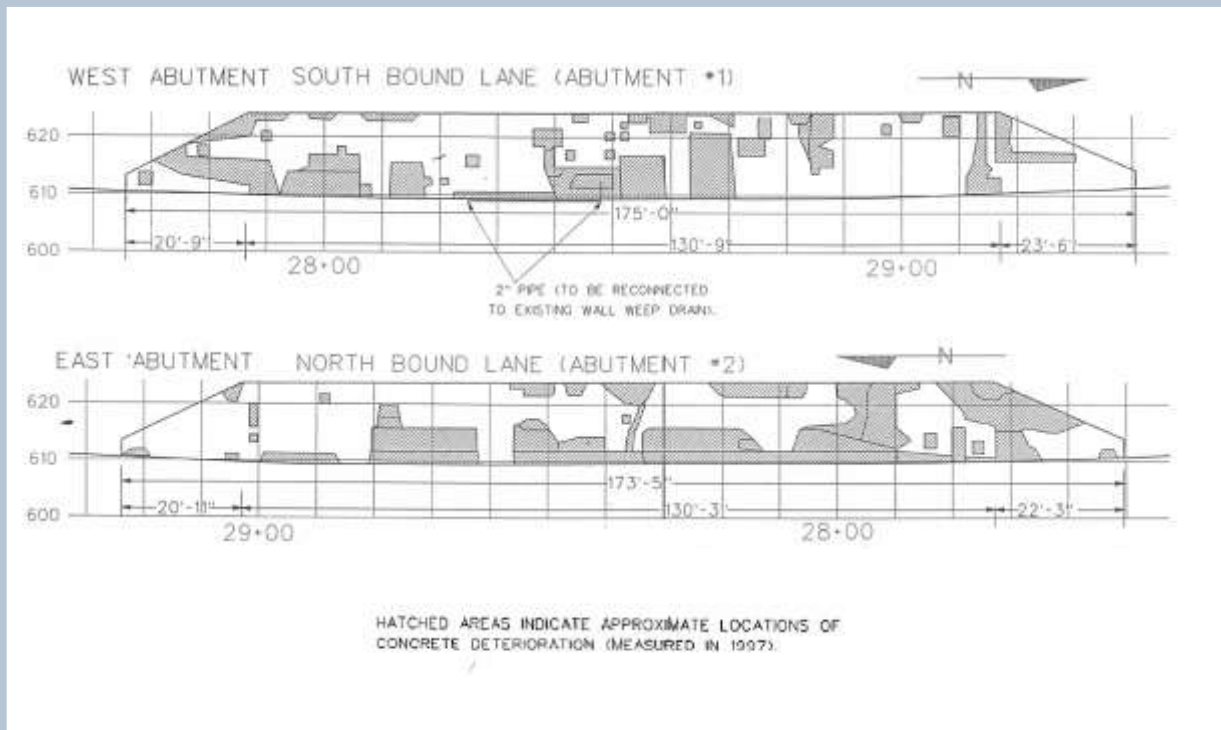
STRUCTURE DETAILS

Abutments: Reinforced concrete full-height abutments and reinforced concrete wingwalls

Superstructure: 3' reinforced concrete slab

FRP Wrap Usage: MBrace Glass Fiber Reinforced Laminate System applied to abutment walls, edge of deck slab and concrete supporting steel columns

Construction Plans



WINGWALL PRIOR TO REHABILITATION



WINGWALL REPAIRED WITH FRP WRAPS

CFRP Wrap on Abutments and Ends of T-Beams



Wrapping

The Flag Run Bridge is located in Preston County (District 4) at Latitude, Longitude 39.31693, -79.69367 and was originally built in 1940, with FRP installed in 2001 by Ahren and Associates. The single span bridge has an overall length of 43.2 feet with a maximum span length of 40 feet with 14 degrees skew. The deck is 27 feet wide and carries 650 vehicles per day across 2 lanes along the rural road at speeds up to 55 mph.

INSPECTION HISTORY

Most Recent Inspection
4/8/2014

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
75.5

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Fair	Good	Fair

Current FRP Condition: The abutments are in fair condition. Minor spalling and scaling exists at the base of the breastwall and upstream wingwall beneath the carbon fiber wrap. There are a few localized spalls with exposed rebar in the backwall. The T-beams are in good condition.

Applicable Maintenance Issues: None



FRP WRAP ON WINGWALL AND T-BEAM

STRUCTURE DETAILS

Abutments: Full-height concrete abutments

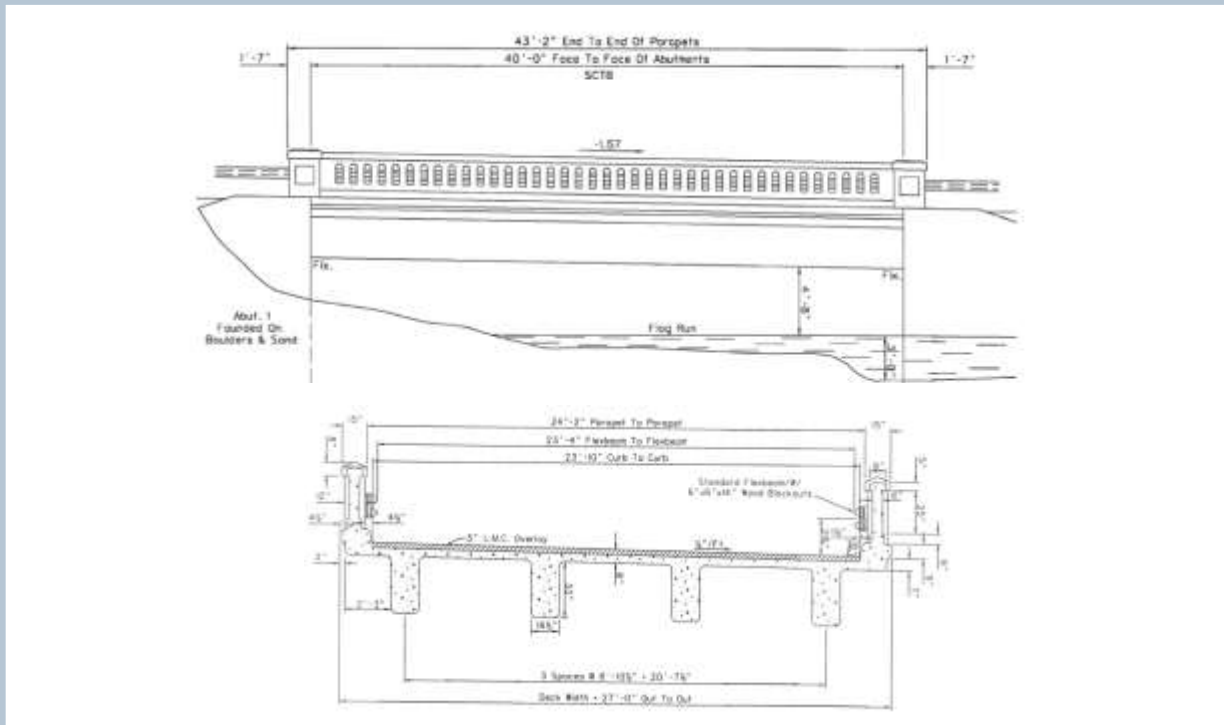
Superstructure: 4 2'-9" x 1'-4.5" concrete beams at 6'-10.5" spacing

Deck: 8" cast-in-place concrete

FRP Wrap Usage: CFRP wrapped abutments and beam ends

Wearing Surface: 3" latex modified concrete

Inspection Sketch



FRP ON END OF T-BEAM



FRP ON T-BEAM, ABUTMENT AND WINGWALL

MADISON AVENUE

BARS: 06A164

GFRP Wrap on Pier Caps and Columns



Wrapping

The Madison Avenue Bridge is located in Cabell County (District 2) at Latitude, Longitude 38.40827, -82.48253 and was originally built in 1966, with FRP installed in 2014 by WVDOT-DOH and WVU. The three span bridge has an overall length of 118.2 feet with a maximum span length of 57.5 feet with no skew. The deck is 64.8 feet wide and carries 16,900 vehicles per day across 4 lanes on at speeds up to 55 mph.

INSPECTION HISTORY

Most Recent Inspection
6/3/2014

Design Load
HS-20

Unofficial FHWA Sufficiency Rating
96

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Good	Good	Good

Current FRP Condition:

The reinforced concrete open column piers are in good condition. No significant deficiencies currently exist.

Applicable Maintenance Issues:

In 2014, FRP wraps used to rehabilitate piers 1 and 2 due to deterioration due to rebar corrosion leading to failure of concrete cover.



INSTALLATION OF THE FRP WRAP

STRUCTURE DETAILS

Abutments: Reinforced concrete stub abutments on spread footings and reinforced concrete piers on spread footings.

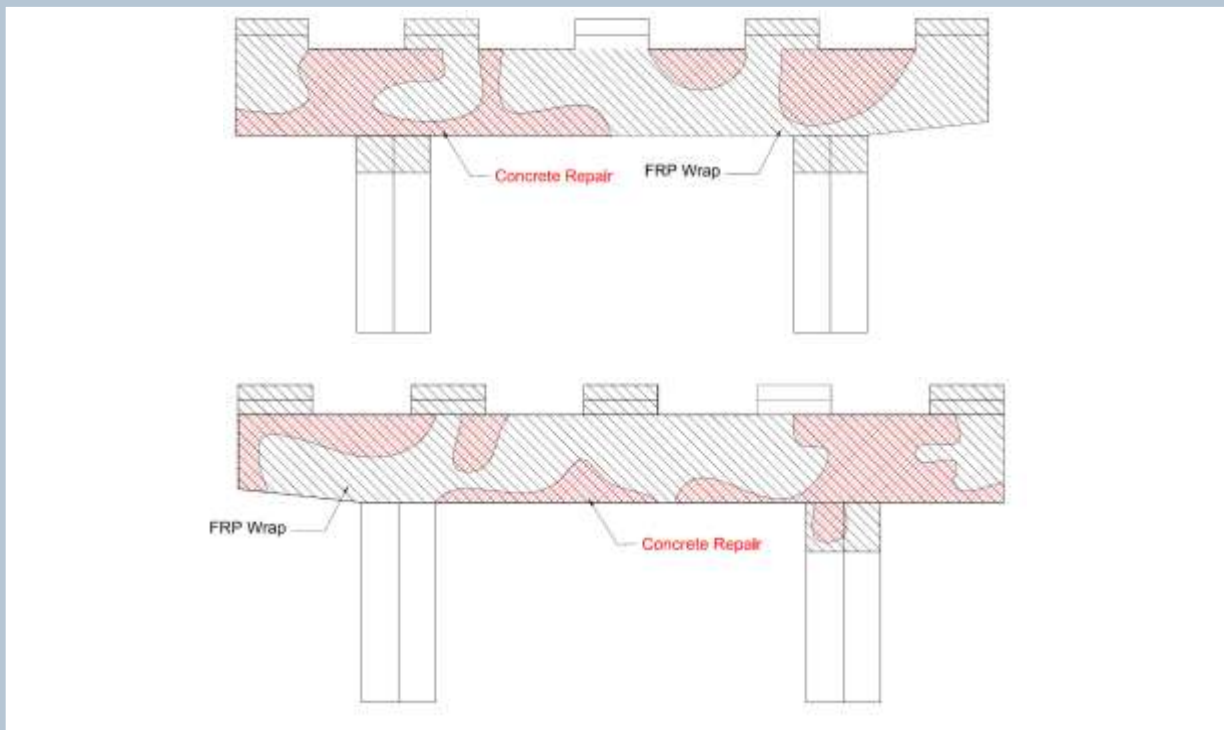
Superstructure: 5 W36x135 beams at 7'-0" spacing

Deck: 7 cast-in-place concrete

FRP Wrap Usage: Aquawrap® G-03 and G-05 on pier caps and columns

Wearing Surface: 7" asphalt

FRP Repair Plans



CONCRETE DETERIORATION PRIOR TO REPAIR



REPAIRED PIERS

MUDDY CREEK

BARS: 39A053

CFRP Wrapped T-Beams



Wrapping

The Muddy Creek Bridge is located in Preston County (District 4) at Latitude, Longitude 39.54436, -79.63021 and was originally built in 1943, with FRP installed in 2000 by Ahern & Associates. The three span bridge has an overall length of 129 feet with a maximum span length of 41.7 feet with 30 degrees skew. The deck is 29.7 feet wide and carries 2,500 vehicles per day across 2 lanes at speeds up to 55 mph.

INSPECTION HISTORY

Most Recent Inspection
2/28/2013

Design Load
H-15

Unofficial FHWA Sufficiency Rating
80.9

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Very Good	Very Good	Good

Narrative Rating:

The T-beams are in good condition. Sporadic cracking and peeling is present in the epoxy coating over the carbon fiber wraps.

Applicable Maintenance Issues:

In 2000, the T-beams 1 and 4 were strengthening with CFRP wraps in all spans due to general deterioration.



FAILED EPOXY COATING

STRUCTURE DETAILS

Abutments: Concrete spill through abutments

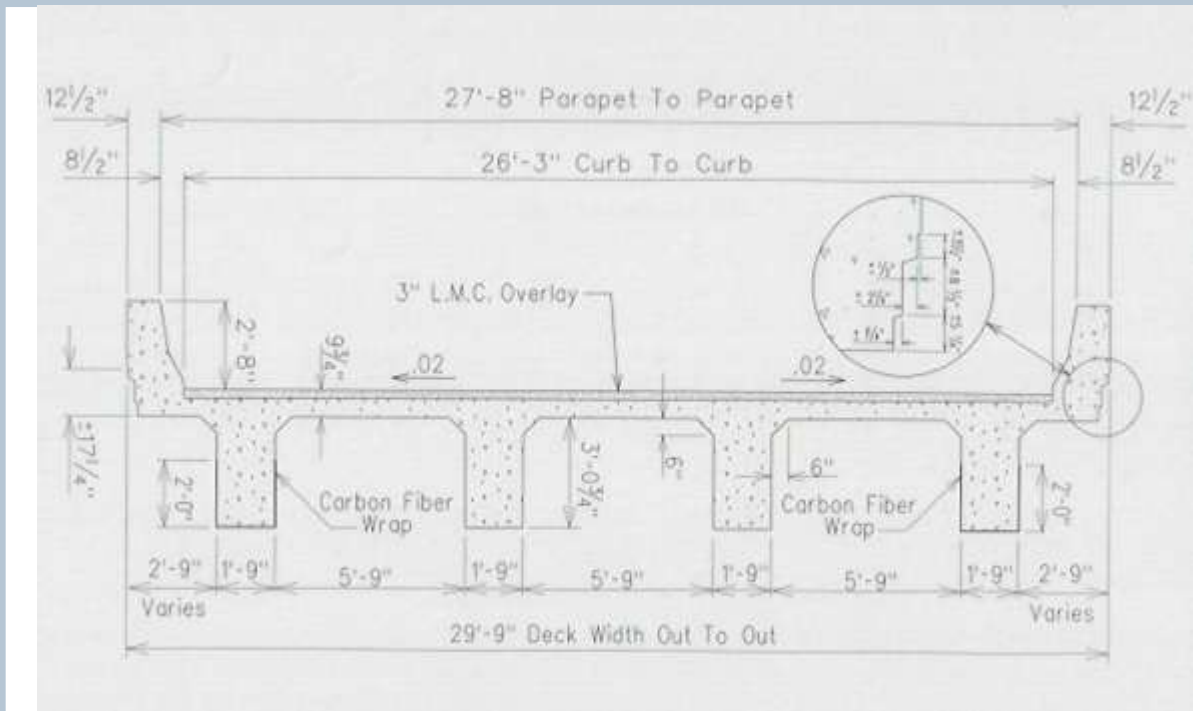
Superstructure: 4 concrete T-Beams (1'-9" high) at 7'-5" spacing

Deck: 9.75" cast-in-place concrete

FRP Wrap Usage: T-beams 1 and 4 wrapped with CFRP in all spans

Wearing Surface: 3" latex modified concrete

Inspection Sketch



CFRP WRAP INSTALLATION



BLUE EPOXY WRAP PRIOR TO PAINTING

BARRACKVILLE COVERED

BARS: 25A065

GFRP Rods Reinforcing Timber Truss



Superstructure

The Barrackville Covered Bridge is located in Marion County (District 4) at Latitude, Longitude 39.506051, -80.167899 and was originally built in 1853, with FRP installed in 1999 by Orders Construction Company. The single span bridge has an overall length of 150 feet with a maximum span length of 131 feet with no skew. The deck is 16 feet wide and has been closed to vehicular traffic since 1985, but is preserved as a pedestrian crossing.

INSPECTION HISTORY

Most Recent Inspection
2/4/2014

Design Load
85 lbs/ft²

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Good	Fair	Good

Current Truss Condition:

The timber Burr Arch type trusses are in fair condition.

Applicable Maintenance Issues:

Completely renovated in 1998-1999



GFRP ROD EMBEDDED INTO DIAGONAL MEMBER

STRUCTURE DETAILS

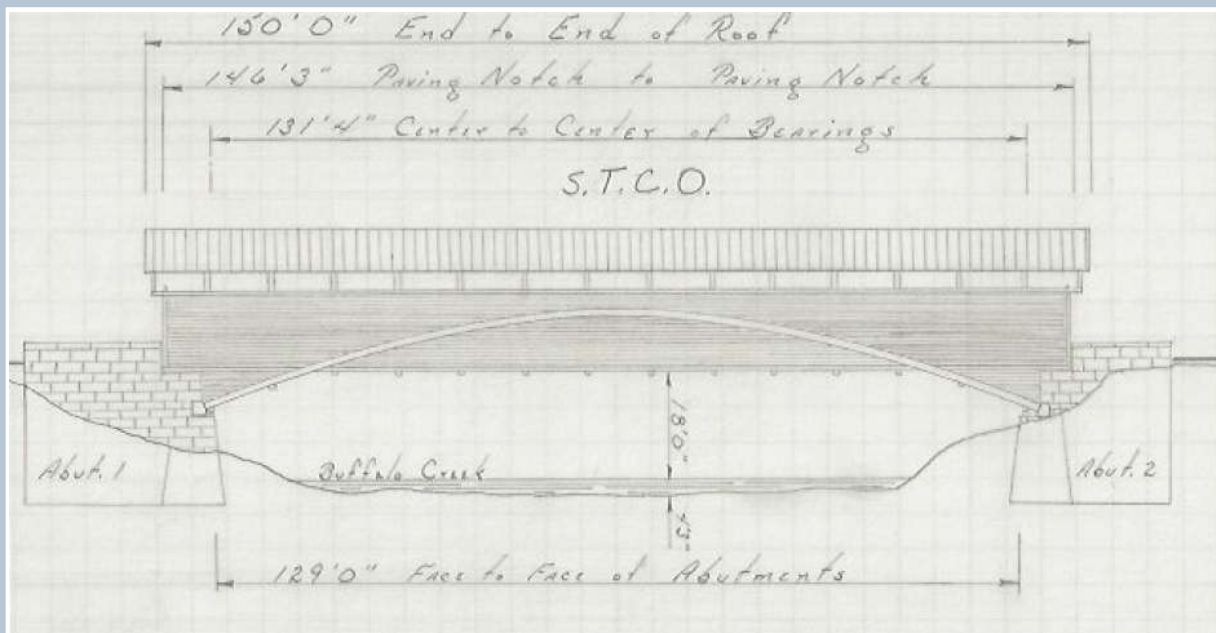
Abutments: Full-height cut-stone abutments on unknown foundations

Superstructure: Timber Burr Arch

Deck: Timber

Wearing Surface: N/A

Inspection Sketch



RESTORATION OF MAIN ARCH



EPOXY GROUTED GFRP REINFORCEMENT

BLANNERHASSETT ISLAND BRIDGE

BARS: 54A200

Bedford Reinforced Plastics Inspection Walkway



The Blennerhassett Island Bridge is located in Wood County (District 3) at Latitude, Longitude 39.27573, -81.64673 and was originally built in 2008. The twelve span bridge has an overall length of 4009 feet with a maximum span length of 878.5 feet with no skew. The bridge 16300 vehicles per day across 6 lanes on the Appalachian Corridor H highway. An inspection walkway, safety ladders and security shaft and conduit under the bridge are all GFRP.

Inspection Walkway

INSPECTION HISTORY

Most Recent Inspection
5/2/2014

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
71

Narrative Rating:

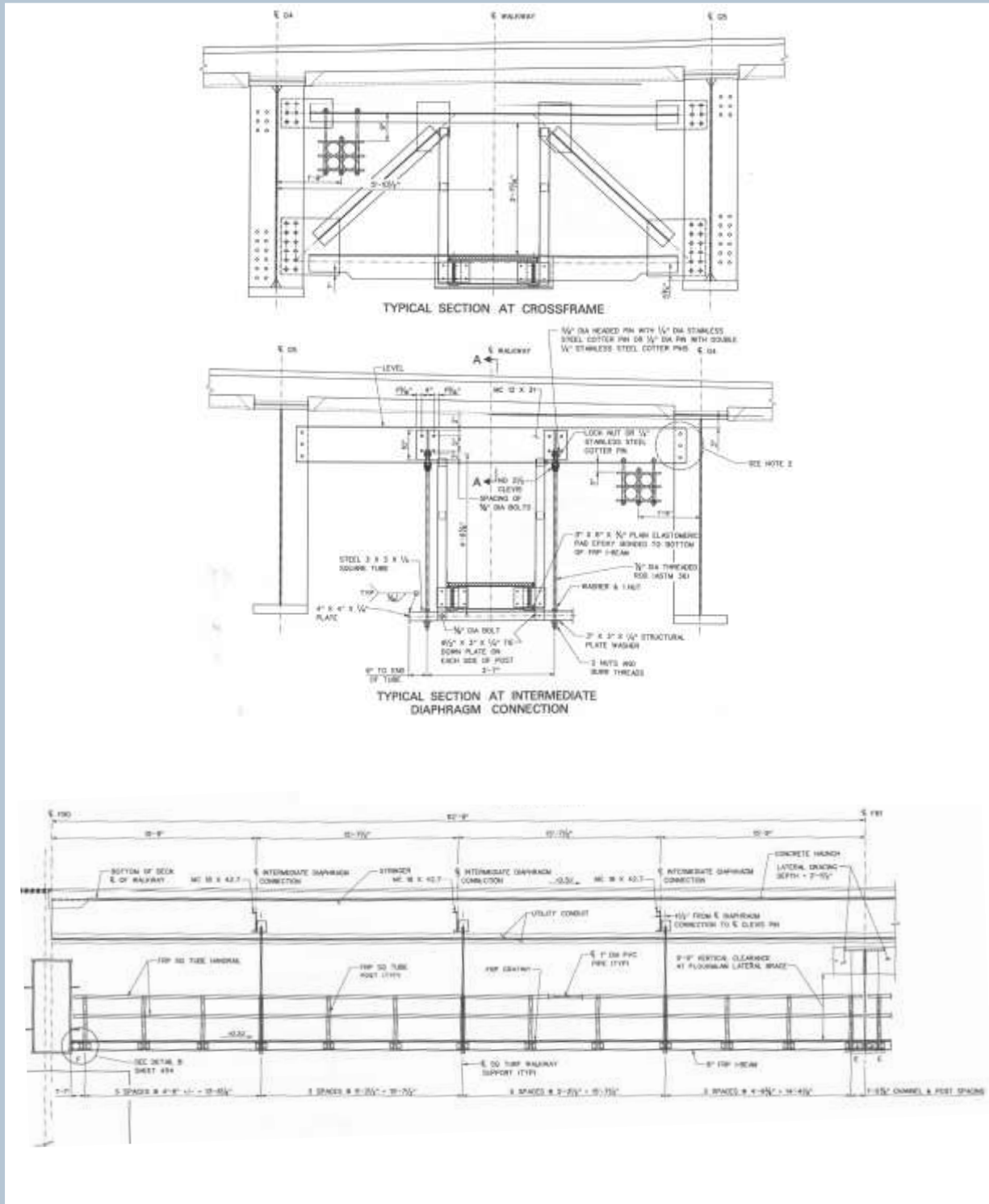
The inspection walkway is holding up well, though it is not as stiff or rigid as steel, so it has some bounce to it, comparatively. The safety ladders are fine. The security shafts surrounding the ladders are much flimsier than steel. This is considered a good thing, as it makes trespassers think about climbing down them. The security shafts are showing some UV damage, as some of the fibers are visibly coming through. The conduits and large junction boxes are also FRP, and along with the cat walk, are not subjected to UV rays, and are all fine.

Applicable Maintenance Issues:

None

STRUCTURE DETAILS

Plan Details



Kansas Structural Deck (removed in 2010)



Failed Deck System

The Hanover Bridge is located in Pendleton County (District 8) at Latitude, Longitude 38.60915, -79.35308 and was originally built in 1976, with FRP installed in 2001 by Hoke Brothers. The two span bridge has an overall length of 118.4 feet with a maximum span length of 56.5 feet with no skew. The bridge is 28.2 feet wide and carries 650 vehicles per day across 2 lanes on the rural paved road at speeds up to 45 mph.

INSPECTION HISTORY

Most Recent Inspection
8/7/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
85.0

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Very Good	Fair	Satisfactory

Narrative Rating:

Deck and wearing surface in rated as fair in 2003, and poor in 2005, 2006 and 2007.

Applicable Maintenance Issues:

In June 2004, the District Eight Repair Crew straightened and tightened numerous loose deck clips. Additional shims were installed between the deck underside and the top flanges of the stringers. A steel plate was installed in over the failed deck panel in the downstream lane near Abutment 1.

In November 2010, the FRP deck was removed and a new ExoDermic concrete deck was installed.



DECK TO STRINGER CONNECTOR

STRUCTURE DETAILS

Abutments: Full height reinforced concrete abutments

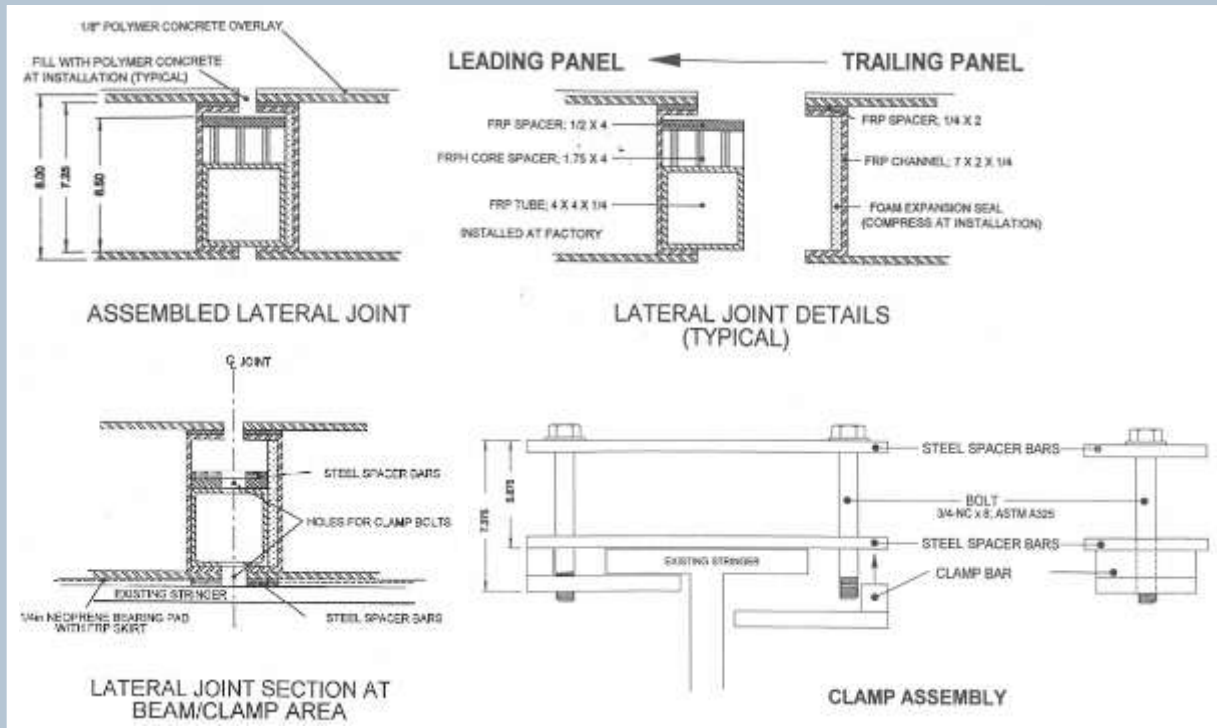
Superstructure: 7 W33x130 beams at 4'-4" spacing

Deck: 8" Kansas Structural deck

Deck-to-Stringer Attachment: Clamp assembly

Wearing Surface: 1/8" polymer concrete

Elevation View



FRP DECK AND CURB

Creative Pultrusions Superdeck and FRP Angles as Truss Members



The Katy Truss Bridge is located in Marion County (District 4) at Latitude, Longitude 39.51049, -80.21595 and was originally built in 1912, with FRP installed in 2001 by WVDOT-DOH District 4 Bridge Forces and Creative Pultrusions. The single span bridge has an overall length of 90.1 feet with a maximum span length of 90.1 feet with no skew. The bridge is 13.9 feet wide and carries 550 vehicles per day on the 1 lane bridge.

Deck System and Superstructure

INSPECTION HISTORY

Most Recent Inspection
12/17/2013

Design Load
H-20

Unofficial FHWA Sufficiency Rating
74.5

WVDOH Inspection Appraisal Ratings

Deck	Superstructure	Substructure
Good	Satisfactory	Good

Current FRP Condition: The deck is in good condition. Water pools on the deck due to low spots in the FRP deck. The wearing surface is in good condition, with the only deficiency observed was the existence of transverse, hairline cracks over all the floorbeams.

Applicable Maintenance Issues: Truss was completely renovated in 2001 when FRP deck was installed. Polymer concrete wearing surface reported loose and missing throughout the bridge in 2007 and was replaced with a epoxy urethane copolymer overlay by state forces in 2010.



WATER STANDING ON DECK

STRUCTURE DETAILS

Abutments: Full height cut stone on sand/gravel (Abutment 1) and rock (Abutment 2)

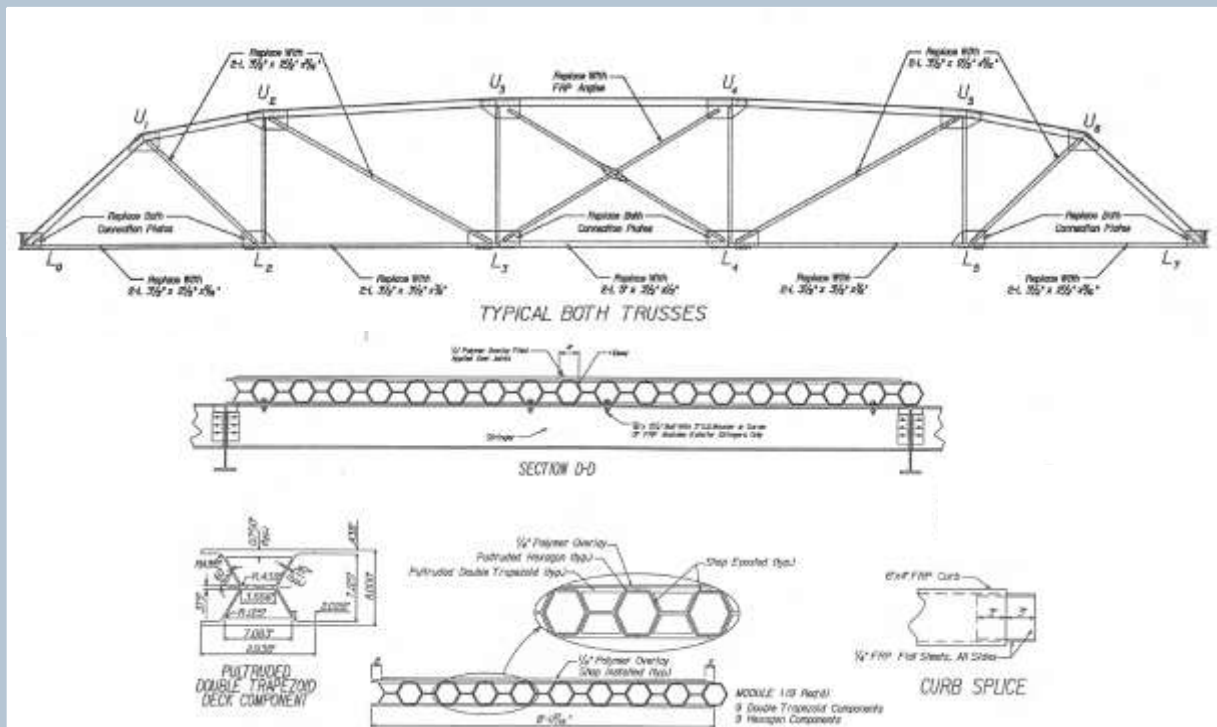
Superstructure: Steel camel back Pratt trusses, with 2 FRP angles used as truss members L3U4. Deck supported on W21x57 floorbeams at 18' spacing resting on W14x61 stringers at 6' spacing.

Deck: 8" Creative Pultrusions Superdeck

Deck-to-Stringer Attachment: Bolted and bonded to stringers

Wearing Surface: 1/2-3/4 inch polymer overlay

Plan Details



PLIOGRIP FOR DECK TO DECK CONNECTION



DECK PRIOR TO WEARING SURFACE INSTALLATION

LAUREL LICK

Creative Pultrusions Superdeck with GFRP Wide Flange Beams and Piling



The Laurel Lick Bridge is located in Lewis County (District 7) at Latitude, Longitude 39.019237, -80.350572 and was originally built in 1997 by the WVDOT-DOH. The single span bridge has an overall length of 20 feet with a maximum span length of 19 feet with no skew. The bridge is 16 feet wide and carries little traffic at low speed along a 1 lane gravel road.

Deck, Superstructure and Substructure

INSPECTION HISTORY

The Laurel Lick Bridge is under 20 feet, and thus not subject to the NBI inspection standards. The condition reported herein is based on the comments from the District 7 Bridge Engineer.

Narrative Rating:

The deck and wearing surface are holding up fine.

Applicable Maintenance Issues:

FRP curb was replaced after being damaged by a large vehicle.



GFRP PILES/CELLULAR LAGGING MODULES

STRUCTURE DETAILS

Abutments: Reinforced Concrete integral abutments on GFRP piles/lagging

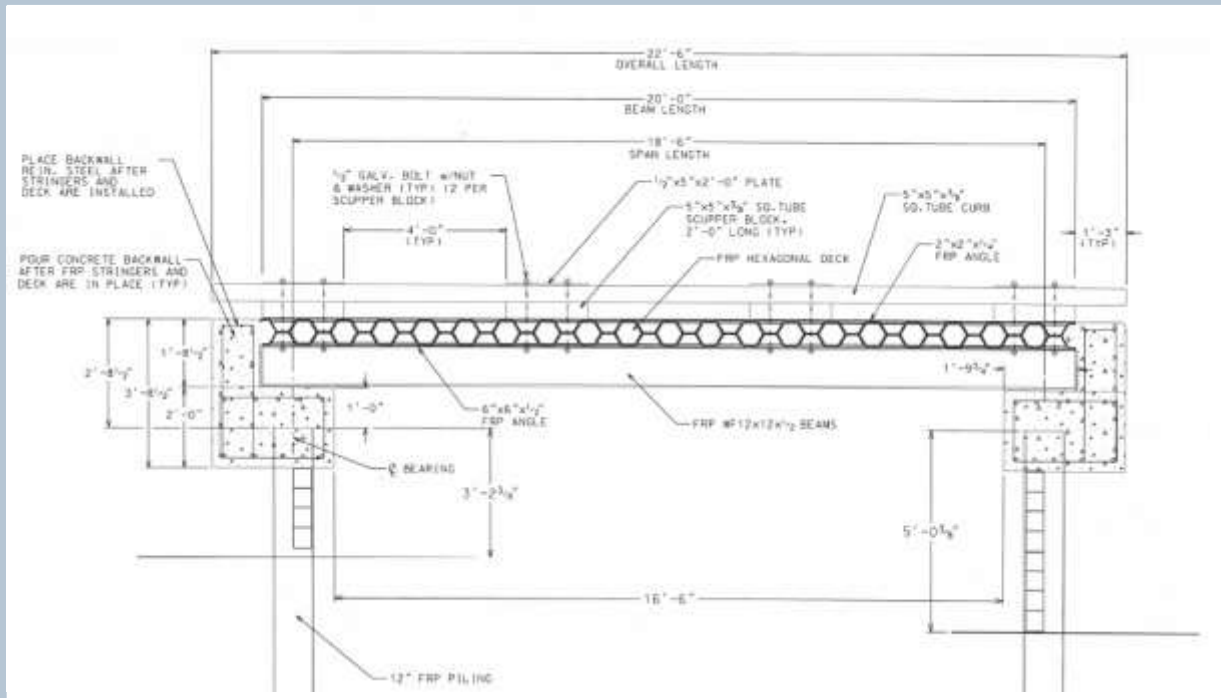
Superstructure: 6 W12x12x1/2 beams at 2'-6" spacing

Deck: 8" Creative Pultrusions Superdeck

Deck-to-Stringer Attachment: Pliogrip adhesive and blind bolts

Wearing Surface: 1/2" polymer concrete

Elevation View



APPLICATION OF PLIOGRIP ADHESIVE TO GFRP BEAMS



INSTALLATION OF DECK PANELS

ROBERT BEECH (WEST BUCKEYE)

BARS: 31A290

Kansas Structural Deck (removed) and CFRP Reinforcement Glulam Arches



Superstructure and Failed Deck System

The Robert Beech (West Buckeye) Bridge is located in Monongalia County (District 4) at Latitude, Longitude 39.71304, -80.11637 and was originally built in 2003 by Turman Construction. The single span bridge has an overall length of 148.7 feet with a maximum span length of 140.3 feet with no skew. The deck is 36 feet wide and carries 1400 vehicles per day across 2 lanes along the rural road at speeds up to 50 mph.

INSPECTION HISTORY

Most Recent Inspection
11/20/2013

Design Load
HS-25

Unofficial FHWA Sufficiency Rating
90.1

WVDOH Inspection Appraisal Ratings:

Deck	Superstructure	Substructure
Very Good	Good	Very Good

Current Arch Condition: Both arches and the connections are in good condition. There is a gouge on the bottom inside face of the upstream arch between the #3 and #4 floorbeam hangers. Delaminations and areas with minor splitting were observed in both arches, particularly at the apex.

Applicable Maintenance Issues: Steel plates were placed over failing deck panels in November 2006 and again in October 2007. FRP deck and sidewalk replaced in May 2009 with Exodermic deck.



PATCHES IN WEARING SURFACE DUE TO FRP DECK FAILURE

STRUCTURE DETAILS

Abutments: Concrete semi-integral abutments

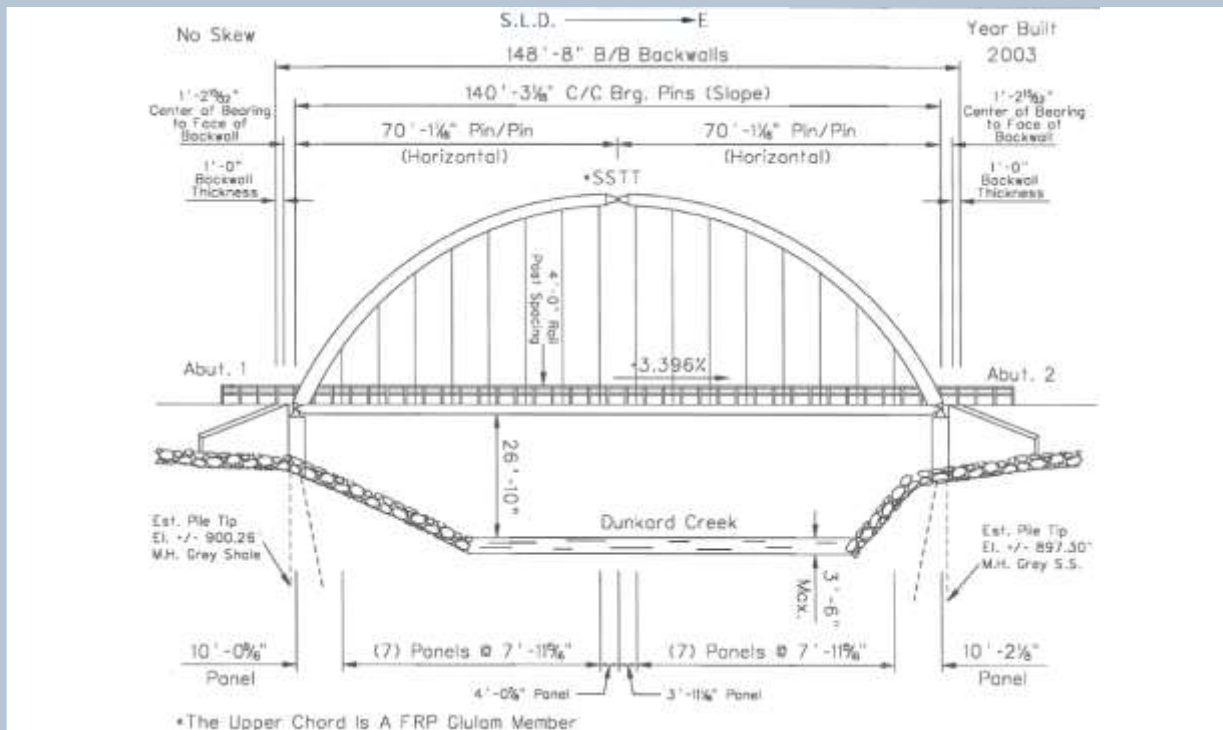
Superstructure: Carbon fiber reinforced timber glulam bow string arch

Deck: Kansas Structural deck from 2003 to 2009. Precast concrete Exodermic from 2009 to present.

FRP Deck-to-Stringer Attachment: Unknown

Wearing Surface: Asphalt

Inspection Sketch



DISPLACEMENT OF FRP DECK



LOCALIZED FAILURE OF FRP DECK