Montana Department of Transportation
Research Programs
November 2018

FINAL REPORT

GEOSYNTHETIC REINFORCED SOIL - INTEGRATED BRIDGE SYSTEM (GRS-IBS)

Location:	Highway 89 (P-3/C000003), Pondera County-South Fork Dry Fork Marias River Crossing
Project Name:	S.E. of Dupuyer – S.E.
Project Number:	STPP NHTSA 3-3(23)65
FHWA Project Number:	MT-12-04
Project Type:	Geosynthetic Reinforced Soil - Integrated Bridge System Installation (GRS-IBS)
Principal Investigator:	Craig Abernathy, Experimental Project Manager (ExPM)
Contractor:	Scarsella Bros./GRS – Tamietti Construction/Deck Installation
Date of Installation:	Fall 2013
Date of Inspections:	July 2014, June 2015, April 2016, May 2017 & May 2018

Objective

The structure built at the South Fork Dry Fork Marias River crossing was been selected for an innovative technology that has been tested in other states and has been proven to work. The new bridge is built with Geosynthetic Reinforced Soil (GRS) Integrated Bridge system (IBS) technology. GRS-IBS is a system that uses a series of alternating layers of granular fill material and fabric sheets of geotextile to create a composite reinforcement that provides support for the bridge slab.

The combination of the compressive strength of the granular soil and the tensile strength of the geotextile results in a very strong internally supported structure that is able to handle a substantial load. Furthermore, this design provides a smooth transition from the roadway to the bridge since the construction is jointless and has no approach slab. Another potential benefit to choosing this type of bridge design is that construction time of the structure may be reduced due to a number of factors. Very little concrete is used compared to conventional abutment designs, which can take up a sizeable amount of project time. On past projects, significant cost savings are realized through the combination of reduced labor costs from shorter construction time due to simpler construction techniques.

Evaluation Procedures

Research will document the installation for best practice and any construction concerns germane to the performance of the GRS/IBS structure. Special consideration will entail documenting the placement of the alternating layers of compacted granular fill supported with the selected geosynthetic reinforcement (TenCate Mirifi HP570), facing (block) wall unit, wing wall, pre-cast beam placement, pavement approach, and other pertinent events.

Semi-annual inspections (late fall/early spring) will report on GRS/IBS integrity and any other visually measurable outcomes. Additional site inspections may supplement the semi-annual visits based on need. Monitor and report on long-term performance and condition for a minimum of sixty months (5 years).

Construction Documentation: Will include information specific to the installation events.

Post Documentation: Will entail semi-annual site inspections for inclusion into the current construction report located at:

Initial Remarks

The information presented in this report encompassed a period from June to November of 2013 involving ten site inspections. District staff did an excellent job informing Research when events of installation had progressed to the point when documentation needed to take place.

This report attempts to capture the pertinent elements of construction to describe the installation events to give the reader an understanding on how this type of structure was assembled. This report also establishes a baseline of documentation for use in determining future performance of the GRS-IBS structure. As noted semi-annual site evaluations will be added annually to the construction report.

One issue with the project was from poor logistics by the contractor in getting the appropriate and approved project materials on site; specifically, the concrete masonry unit (CMU) solid core and split-face hollow core block used for the structures face of the GRS abutment wall. It was also reported the GRS backfill material was difficult to locate due to the gradations requirements. Also, the contractor evidently did not adequately prepare or train their project managers or workers in the basic elements of assembling this type of bridge support. This and other minor issues, including weather delays, led to an extended construction schedule of the GRS-IBS installation.

Other than the issues stated above, once construction began the contractor's team exhibited (overall, with a few exceptions as stated in this report); good attention to detail in the assembly stages of the GRS abutment.

Due to the inexperience of the team, the learning curve necessary to understand what needed to be done extended the installation time substantially to completion. It is reported the north GRS abutment 2 took nearly a month to complete with the south abutment 1 section about half that time. MDT staff was an integral component in the training of the team and in oversight with getting the project completed.

In what was observed and documented on site, and with consensus with MDT District staff associated with the project; determined that there was no detrimental construction practice with the assembly of abutments 1 & 2 as well as the slab installation that may affect short or long term performance to date. As noted in the report the project paving phase will not happen until spring of 2014.

Research would like to thank Mr. Mike Klette, Great Falls Project Manager, and Mr. Kevin Thielmann, Civil Engineer Technician for the help in the coordination of Research project activities. And a special thanks to Mr. Jay Manuel, Civil Engineering Specialist whose expertise and knowledge of the GRS-IBS installation on-site added value to this report.

The following are representative images and descriptions of the pre-structure and construction activities with the GRS-IBS bridge support and adjacent facilities. Also included in this report will be the ongoing site inspection documentation from 2014 to 2018.

<u>July 2014 Site Inspection (page 28)</u>

The GRS-IBS Dupuyer structure was first checked for deck grade on 10/25/13 post bridge construction. It was then checked on 3/30/14. There was an average of 0.01 ft. (0.3 cm) of settlement on all four corners of the bridge deck.

It was then checked again on 7/29/14 after all construction operations on the roadway were completed. There was an average of 0.07 ft. (2.1cm) of settlement from the original survey on 10/25/13.

Five of the CMU hollow core blocks had cracks (refer to page 30). All to date were in the top tier layers which were rebarred pinned and set with class DD concrete. Note that all cracks emanate from the junctions of two blocks down through the center of the adjacent block beneath. Future inspections will document if this trend continues.

June 2015 Site Inspection (page 32)

The GRS-IBS Dupuyer structure was first checked for deck grade on 10/25/13 post bridge construction. It was then checked on 3/30/14. There was an average of -0.01 ft. (0.03 cm) of settlement on all four corners of the bridge deck from the original survey. The second check of settlement on 7/29/2014 registered at -0.08 (0.2 cm); and third check of settlement on 6/1/2015 was at -0.03 (0.08 cm).

This fluctuation of settlement is considered normal with the GRS-IBS design.

Pavement approaches to slab transition are smooth. As noted in the 2014 inspection several of the fascia CMU blocks were cracked. Several more have cracked; MDT staff has sprayed paint as a locator on the current visible cracks. To date this block cracking is not seen as an indicator of performance.

April 2016 Site Inspection (page 35)

Bridge condition remains the same as reported in 2015. Slab to pavement approach is level with a smooth transition. No additional fascia blocks have cracked since initially reported in 2014.

Minor weeping at the fascia CMU blocks which is considered normal.

Next inspection will be conducted in the spring of 2017.

May 2017 Site Inspection (page 37)

Bridge condition remains the same as reported in 2015. Slab to pavement approach is level with a smooth transition. No additional fascia blocks have cracked since initially reported in 2015.

Minor weeping at the fascia CMU blocks which is considered normal.

The last formal inspection will be conducted in the spring of 2018.

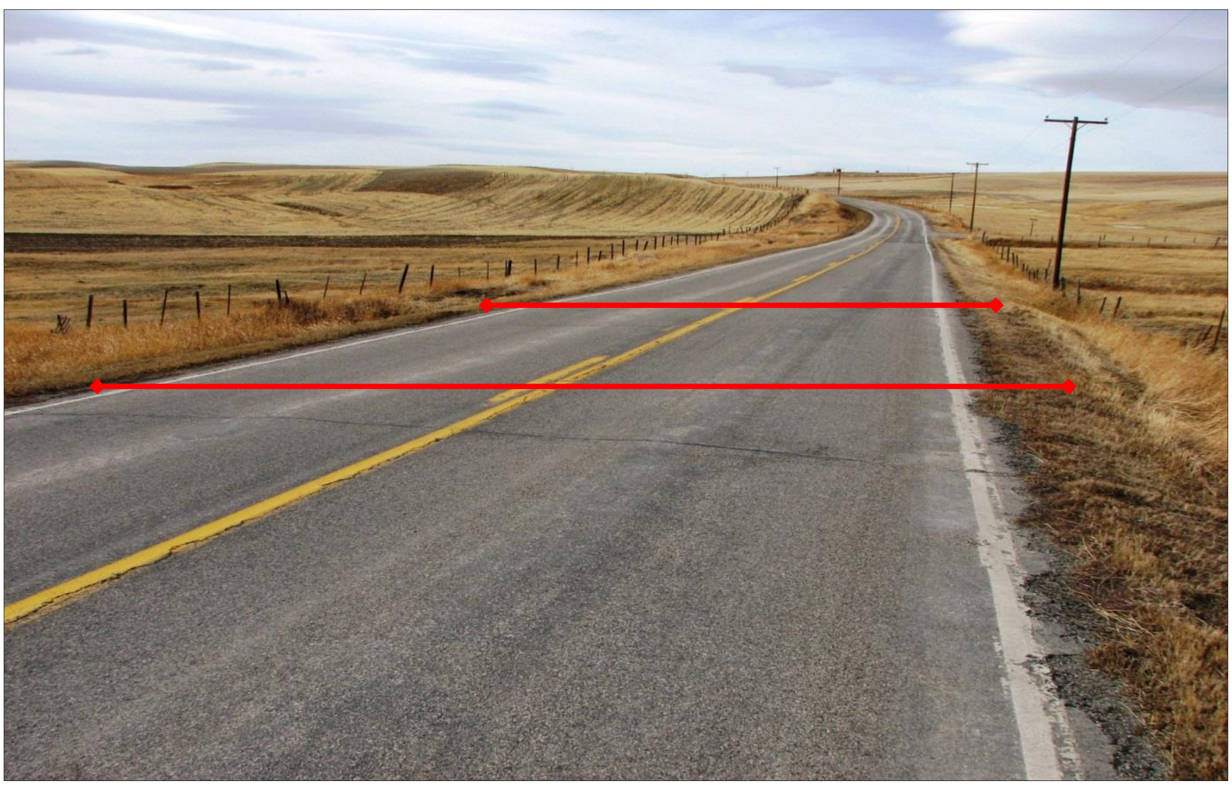
May 2018 Site Inspection (page 38)

No issues to report; condition of structure same as reported in 2017.

This report and other project information may be found at:
http://www.mdt.mt.gov/research/projects/grs_ibs.shtml

Pre-Facility Images – March 2013

🡅 Arial view of preexisting culvert prior to installation of the GRS structure.



🡅 North view of preexisting culvert approximate location (red delineation).

🡅 Eastern side of corrugated steel pipe (CSP) culverts (view north).

🡅 Western side of culverts (view north).

Temporary Culvert and Detour

🡐 A temporary detour directly adjacent (west) to the GRS bridge site is put in place.

🡐 A culvert was installed in the detour to transfer the stream which normally is dry but did have standing water at the time of this documentation. Rip rap was added, and later straw wattles were included.

Construction: June-November 2013

🡐 Excavation begins for the reinforced soil foundation which will be the base of the GRS abutment 2. The view is looking north.

The soil foundation will be encapsulated with geotextile material.

🡐 View of the south abutment 1 preparation for the reinforced soil foundation.

At this time the TenCate Mirifi HP570 geosynthetic material used for the soil foundation and GRS reinforcement layers was on site (red arrow).

🡐 Excessive soil saturation within the GRS abutment sites required the contractor to install a trench in order to drain or wick the water to the base of the channel, where a sump pump removed the standing water.

Once the area was determined adequately drained and stable the trench was filled.

🡐 During this site visit the north GRS abutment 2 has accumulated about ten (10) layers of the friction block facing unit. Geotextile reinforcement layers are applied at a depth of each block face layer at eight (8) inches.

The facing unit (considered a flexible facing element); is used as a façade to serve as a form for compaction, and protect the GRS mass from outside weathering. The red color block (yellow arrow) is solid core; the grey block (red arrow) is standard split-face hollow core (8"x8"x16").

🡐 The workers have installed another layer of HP570 geosynthetic to the top of the GRS mass and begin to position another row of concrete masonry unit (CMU) blocks.

Rip-rap is applied at the base of the GRS and reinforced soil foundation.

The CMU solid core portion of the façade is to aid in scour protection of the abutment.

🡐 Each facing block is carefully positioned and checked for proper placement.

Although not seen in this image, the workers would use pieces of asphalt shingles (as shims) to insure correct vertical and horizontal alignment of the facing block. The rough side of the shingle is placed on the surface of the geosynthetic.

Note that each layer of geotextile is extended to the edge of the CMU (red arrow).

🡐 Once the block layer is complete the next lift of backfill is applied by an excavator while the workers using shovels and rakes spread the fill evenly to the appropriate depth.

🡸 Since this may be the first GRS constructed with a radius design at the abutment corner, the block manufacturer could only supply conventional rectangular CMU block. This created a frontal gap at the radius (yellow arrow).

Because of this gap, it was determined to apply a separation fabric on the interior vertical face (red arrow) in an effort to mitigate any potential movement of fines to the exterior of the radius.

🡸 A closer view of the separation fabric used in the interior of the radius.

🡐 Water was added to aid in required compaction.

Soil moisture averaged around 4%; the moisture specification was 7.4%.

It was reported that one fill layer was overly saturated and had to be removed and replace with new backfill.

🡐 Sample image of plate compactor used to consolidate the GRS mass layers.

Due to compaction some of the hollow core facing blocks were pushed outward and needed to be pounded back flush with the facing wall. These occurrences were minor.

← To further prevent potential migration of fill material through the gap of the radius and for a more aesthetic appearance of the overall abutment structure, the cavities were filled with Sakrete structural hydraulic non-shrink cement (or grout).

← Sample image of grouted radius gap.

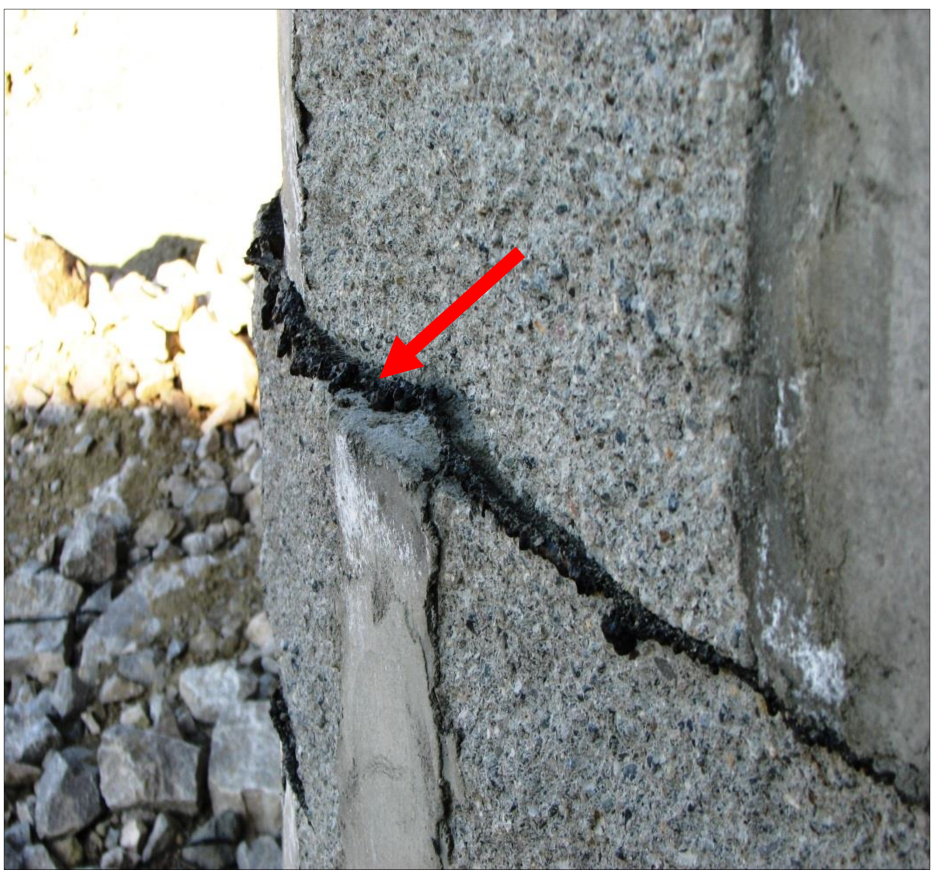
🡐 The north GRS abutment 2 is almost completed. The stream channel is prepared and graded to receive the erosion components.

There are twenty-six (26) subsequent layers of the facing blocks to the beam seat elevation.

🡐 Work progresses on the installation of the south GRS abutment 1 (view west).

🡐 Both north and south abutments are near completion. Erosion control coconut blankets and wattles are in place over the rip-rap, staked down and the stream channel established.

Workers continue grouting the gaps at the radius; rip-rap will be added around the radius (as seen on the north abutment 2, red arrow) once the grouting is complete.



🡐 The Mirifi fabric was removed as much as possible by knife or scissors, however much still remained as seen in previous images.

The contractor elected to use a propane torch to burn and/or melt the remaining sections of geosynthetic material from the abutment facing blocks (red arrow).

🡐 Final preparation for the beam seat. One layer of 2"x8" foam board (yellow arrow) is placed directly behind the last top layer of CMU hollow core. Solid core block is positioned upon the 2" layer of foam board.

One of the purposes of the layer of foam board and solid CMU is to create a barrier to minimize any potential outside environmental factors which may affect the performance of the composite GRS base at the beam seat level.

🡐 Backfill is added in three lifts with geotextile material between each layer ending with a top sheet of geotextile approximately level with the top of the solid core block.

The CMU solid block also ensures a stable form for compaction for the beam seat.

Backfill will then be added in a thin layer over the geotextile in preparation for the pre-cast beam placement.

🡅 The north abutment bearing bed has a topical layer of backfill with an elevation even with the solid core block (yellow arrow). This will insure when the pre-cast beams are set that equal distribution of weight is averaged on the beam seat and the CMU solid core. The foam beneath the solid core will compress if the block is too high or in case the beams have some settlement.

The survey stick (red arrow) in the background represents the centerline of the deck and the limit of the beam seat.

To better secure the top facing blocks (white arrow), they were pinned with no. 4 rebar to a depth of 20" within the core. Rebar penetrated the first two layers of geotextile membrane, once set the hollow core blocks were filled with concrete.

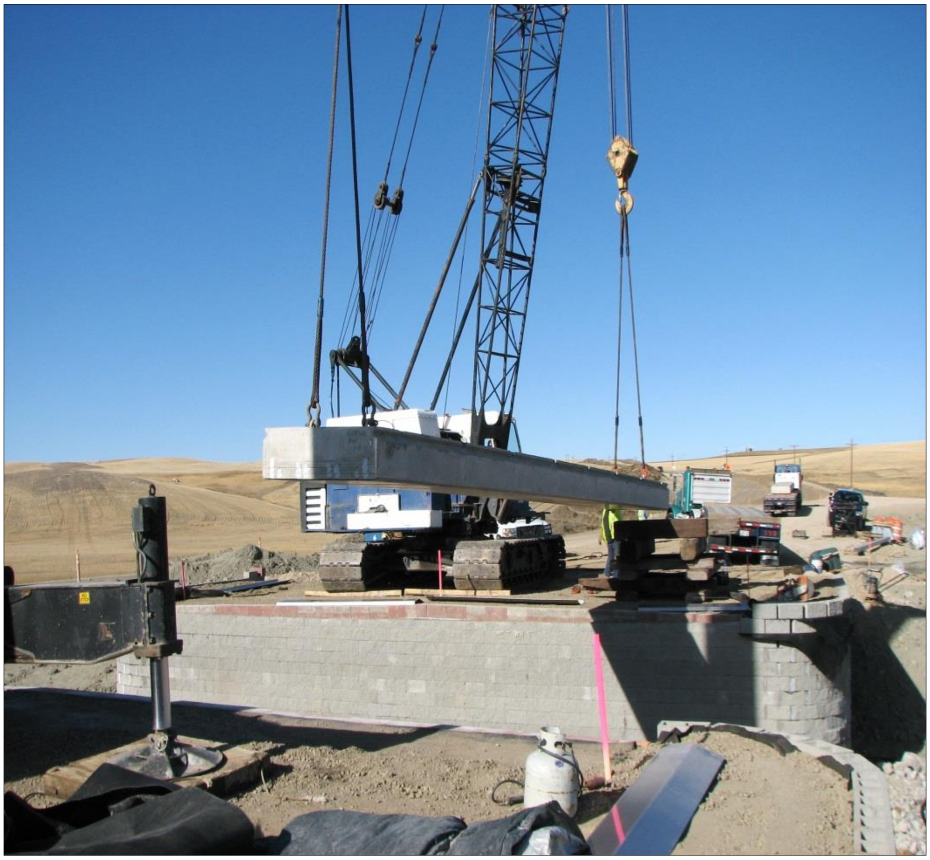
🡅 The north and south abutments are now ready to receive the pre-cast beams. The superimposed yellow line is to show the GRS beam seat is set at an approximate 2% superelevation for deck placement.

The red superimposed line represents the depth of concrete poured and striked off into the fascia CMU hollow core blocks encompassing the beam seat area. As stated earlier, rebar was pinned into each of the cores to a depth of 20" as not to puncture the next layer of geotextile (past the third layer of CMU).

Once the beams are set and the wingwall facings are completed the same scenario of pinning and grouting the first three layers of blocks will be applied.

↑ Both abutments are ready for beam placement (view east).

↓ An aluminum fascia plate is positioned over the solid and concrete filled CMU blocks prior to the laying of the beams. Due to the harsh environment of the bridge location it was determined this added feature will aid in protecting the block and GRS mass from potential long-term deterioration.



🡐 The first of eight (8) pre-cast slabs (measured 18"x52"x38'-8") is lifted by crane to be set to the right of the northbound centerline.

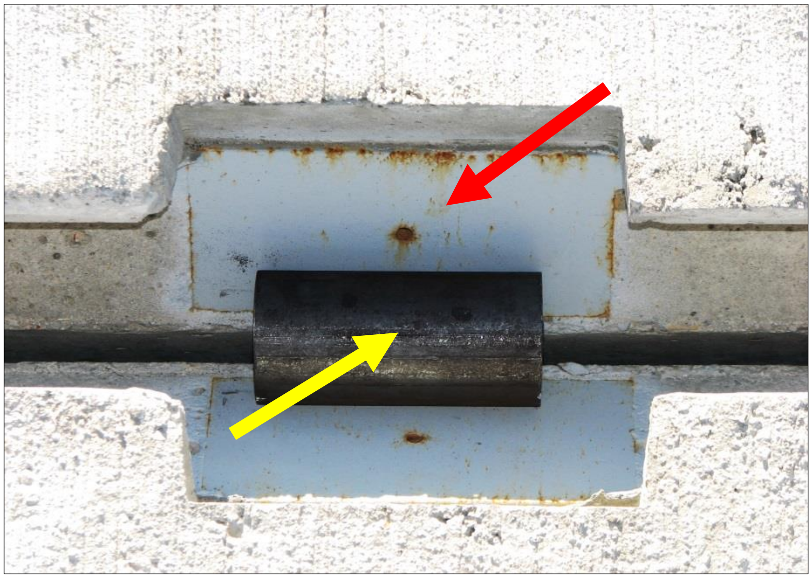
🡐 The workmen were very attentive to correctly place the first girder on the correct point of centerline.

🡸 Both MDT and contractor staff inspect the first interior beam positioning for proper alignment and elevation on abutments 1 & 2.

The slabs are resting on approximately 3 ft. of the beam seat from the CMU solid core block (yellow arrow).

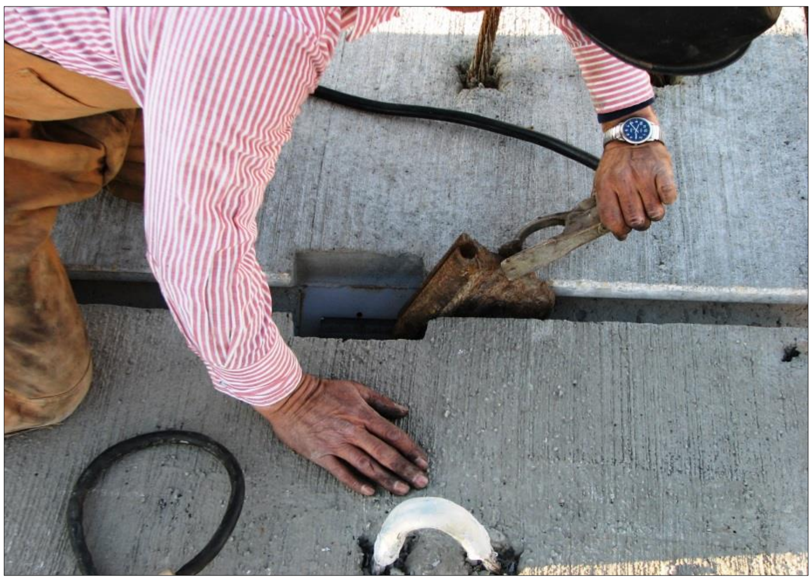
🡸 The remaining interior beams are installed.

🡸 The southbound exterior (curb) beam is positioned on the abutments.



🡐 After the slabs are placed the beam joints have pre-set welded bar and shears studs embedded in the pre-cast slabs (red arrow). A 2"x4" steel rod is laid in the groove channel of the joint to provide a welded tie (yellow arrow).

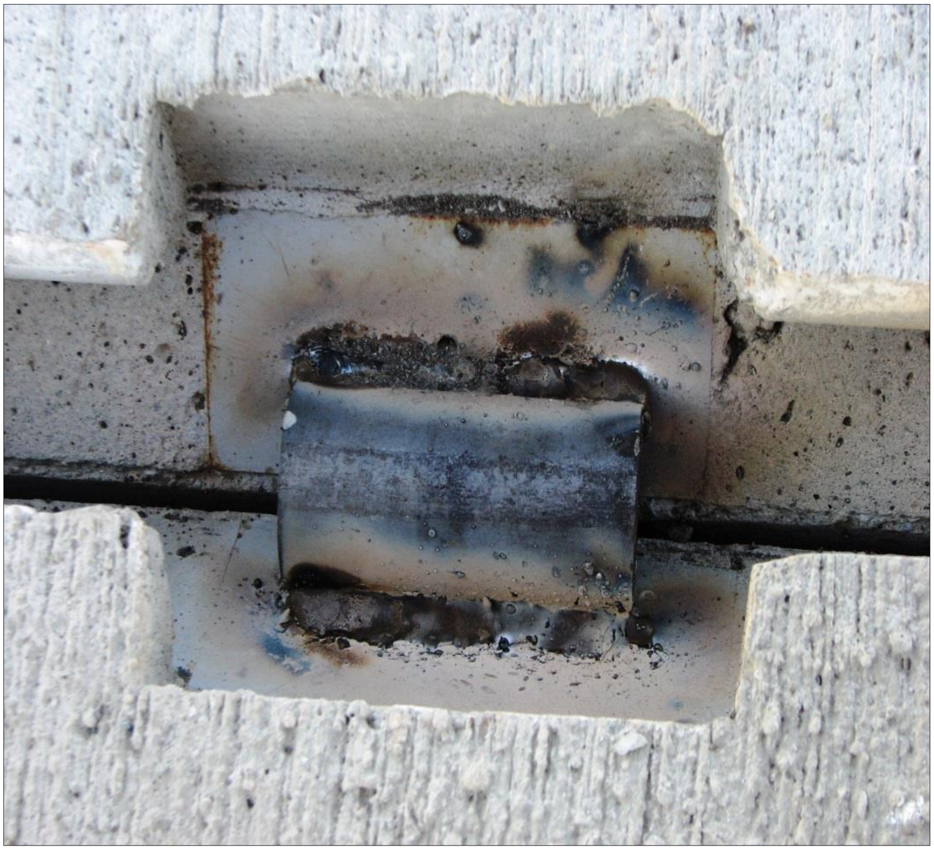
Each seven (7) slab joints will have eight (8) welded ties for a total of 56 for the entire deck.



🡐 To create a ground the worker lays a piece of scrap metal against the bar to complete a circuit for welding.

This had to be done for all 56 welding ties.

🡐 The steel rod is then welded to the bar plate.



🡸 Sample image of rod to plate completed weld.

🡸 Once all ties were welded the gap in the slab joints were plugged with foam backer rod then filled with non-shrink grout as seen in this image.

🡐 Here the deck curb standard bridge rails (type W740) are being installed.

🡐 View of underside of completed deck installation towards abutment 1 (south).

Note the gap between the aluminum fascia and facing blocks (red arrow).

The fascia is meant to cover the top facing block as a protective lip. To date the decision is to attach an extension to the fascia to compensate for the gap.

🡅 View east of the completed GRS abutments and bridge installation. The truck on deck is the recently arrived crew to install the approach guardrails.

🡄 North view of the completed GRS bridge and guardrail installation.

Due to weather constraints the contractor ran out of time for the paving phase and will resume work in the spring of 2014.

In the interim an asphalt and gravel approach will be in place over the winter season.

The contractor did comply in adding the integration zone (geosynthetic reinforcement layers) to the approaches.

🡅 Overview (north) of the completed GRS bridge installation.

🡇 Overview (south) of the completed GRS bridge installation.

🡐 As stated earlier, an approach length of approximate 3 ft. of asphalt cement (AC) was added in an effort to protect the slab during plowing over the winter.

The AC is of low quality and already exhibits signs of distress. It is anticipated the approach will maintain its integrity until it is paved next spring.

🡐 In areas around the wingwall the quality of the grout patching of the radius gaps is substandard near the top layers as seen in this image.

Also, geotextile material between the facing block layers is still visible.

Future site inspections will verify if these issues were corrected.

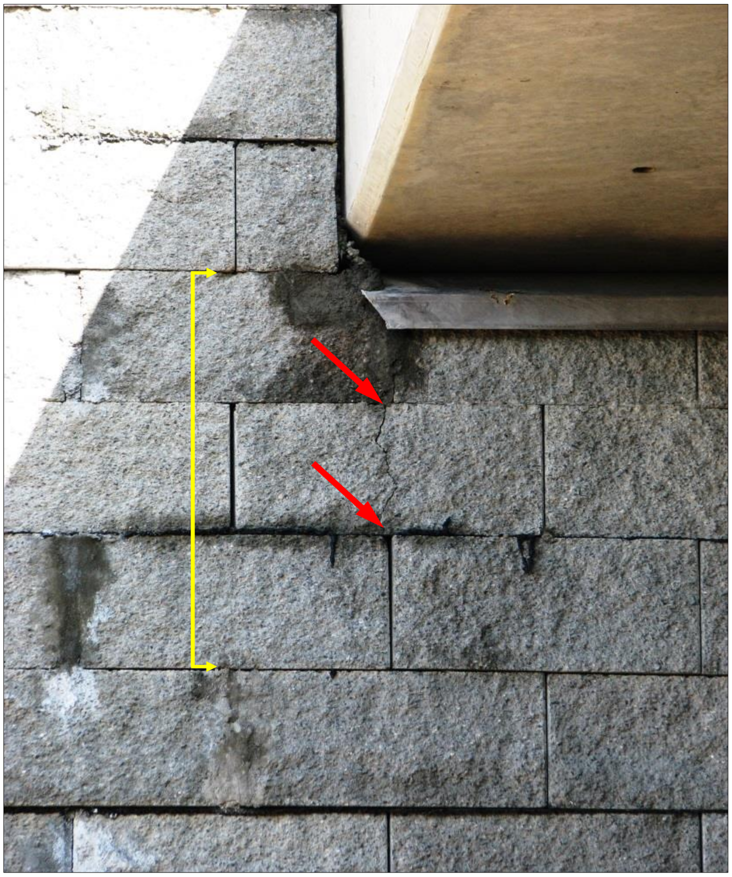
July 2014 Site Inspection

🡅 Completed GRS structure; view south.

🡇 Completed GRS structure; upstream view - east.

🡅 North GRS abutment; active weeping is seen in the is view. This is considered normal for this design.

🡇 The gaps in the wing wall radius have all been patched with mortar.



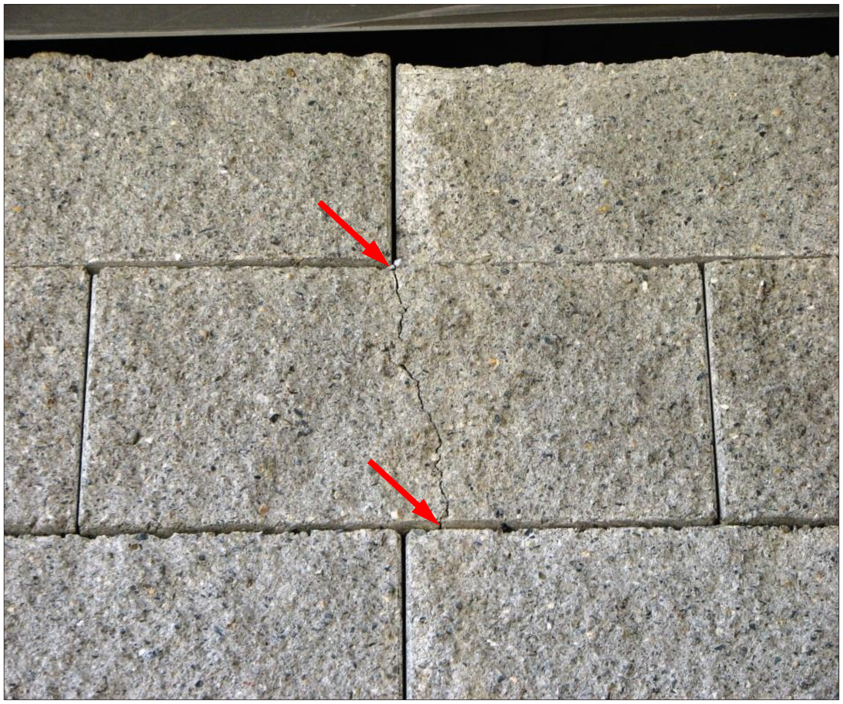
🡸 Cracking has been noticed on the CMU face block.

The location of this crack is just below the deck slab on the north abutment, west side.

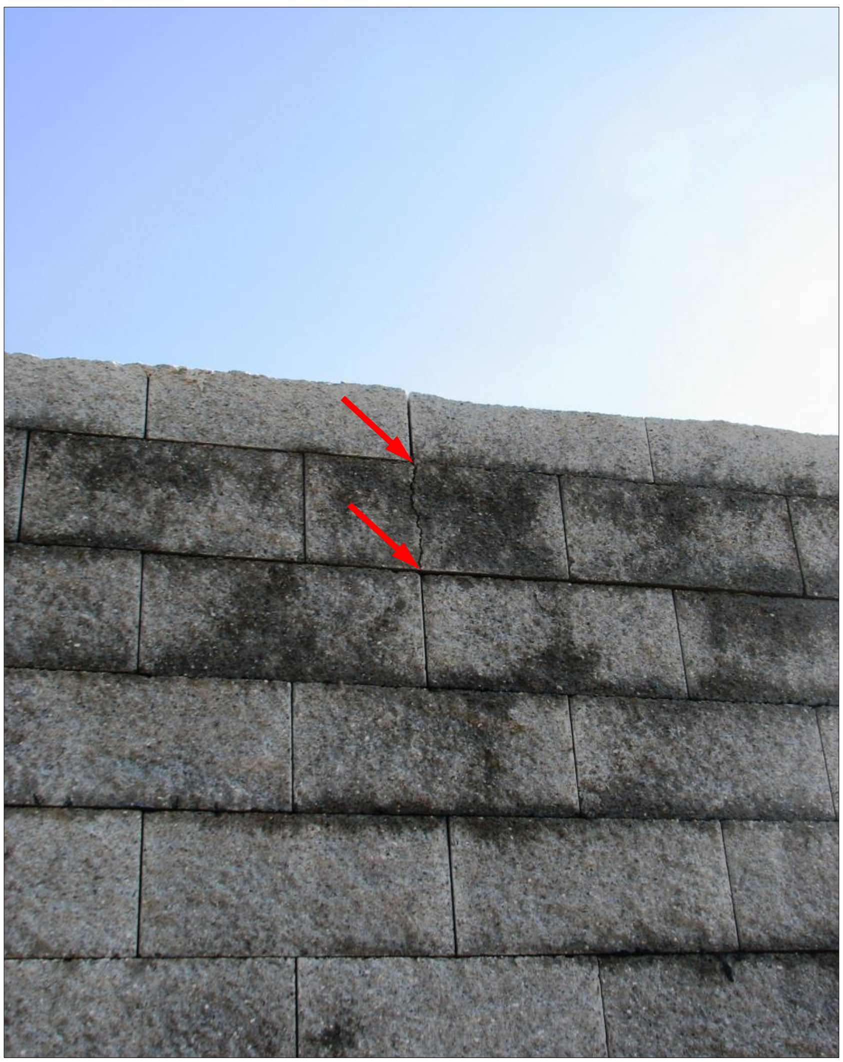
The red arrows show the extent of the crack.

Per specifications, the top three rows of CMU hollow core (at the beam seat) were pinned with no. 4 rebar and set with class DD concrete (yellow bracket).

🡸 Another crack located at the edge of the beam seat at the south abutment, east side.



🡐This cracked block is located center near the top of the south abutment.



🡐 Another cracked block was located on the northwest wingwall.

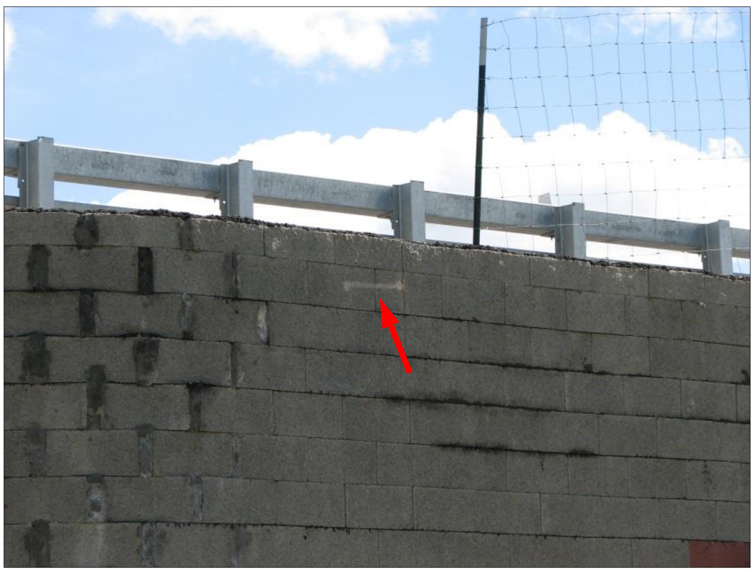
June 2015 Site Inspection

🡅 Top view image of structure; view north.

🡇 Side view image of structure; view east.

🡐 🡓 As documented in the 2014 inspection, several fascia blocks developed cracks (red arrows).

All cracks are located near the top layer of block, or at the edge of the abutment placement.



🡐 MDT District staff has applied paint to visible cracked blocks for reference.

To date about seven (7) blocks have developed cracks since installation.

At this time, it is not considered a performance issue.

🡐 Pavement approach to slab is a smooth transition.

Top photo is the north end, bottom photo; south end of deck

April 2016 Site Inspection

←↓ GRS Bridge: Same general condition as reported in the 2015 inspection, no visual anomalies. No additional fascia CMU block cracking observed. East view; west side of structure.

← South abutment. Areas of weeping through joints in fascia block; which is considered normal for this type of design.

🡅 View south; slab to deck approaches maintains a smooth transition.

🡄 View of south end deck to slab joint.

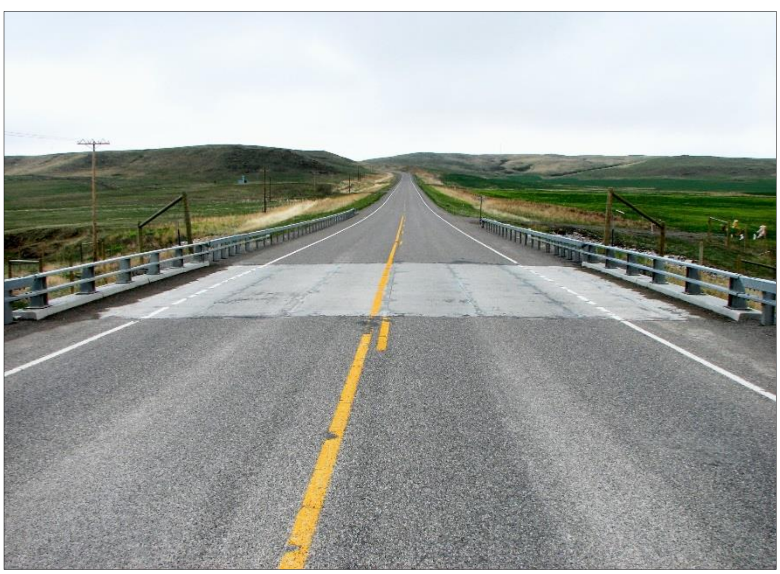
May 2017 Site Inspection

🡐🡓 Representative images of the GRS structure:

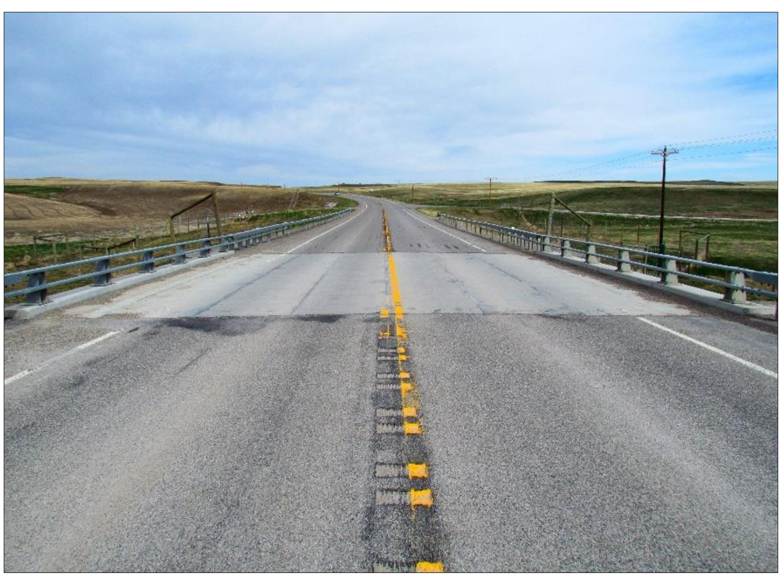
Top image is north abutment; west side.

Center image is south abutment; east side.

Lower image is view of GRS deck (view south).



May 2018 Site Inspection



🡸🡻 Representative images of the GRS structure:

Top image is west side of structure; view east.

Center image is east side of structure; view west.

Lower image is view of GRS deck (view north).

No visual structural issues to report.

Supplemental: Grizzly Bear Fence Crossing

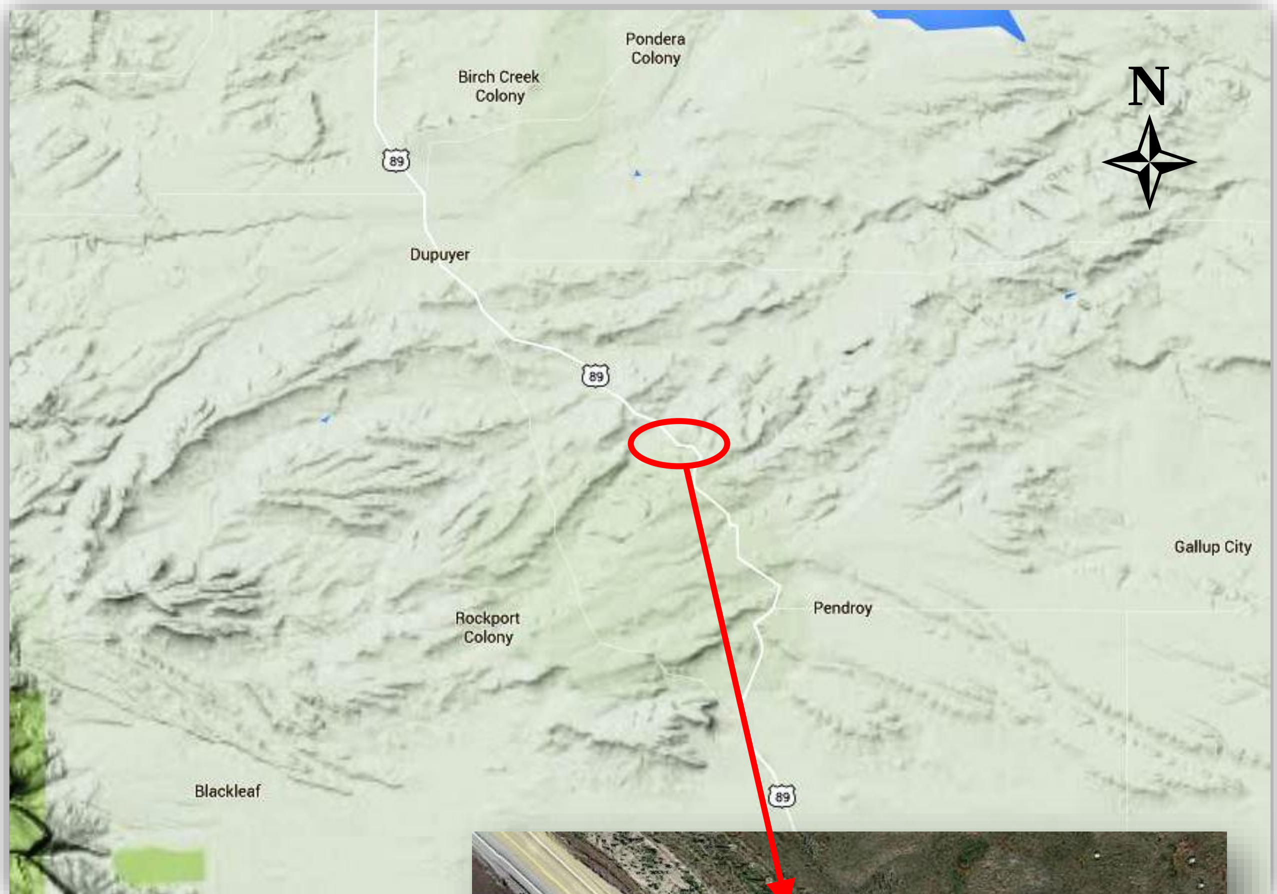
🡅 A wildlife fencing project was installed on the project to steer species of Carnivora Ursidae (aka bears) to use the GRS-IBS as an underpass to circumvent crossing of the highway (view west at southern approach).

One of the unintended consequences of the project was that apparently, animals were permanently affixing themselves to the fence panels. It is unsure whether the animals are bored and like to watch traffic as it goes by; or are just too plain dumb.

Also attached to the fence are several rabbits, a gopher, a raccoon, a dog, an owl and monkey; and one undistinguishable creature we have yet to identify.

We will continue to monitor this unusual event.

Project Location



Highway 89: Pondera County-South Fork Dry Fork Marias River – Approximate Mile Point 71

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