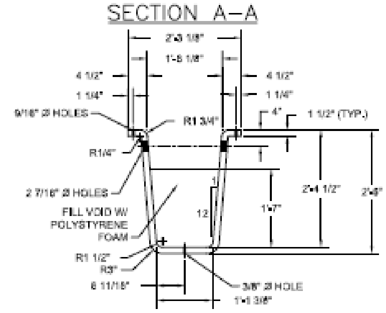


FRP BRIDGE EVOLUTION: TxDOT ADVANCES VIABILITY OF CUSTOM FRP BRIDGE BEAMS IN NEW HYBRID STRUCTURAL CONSTRUCTION RESEARCH PROJECT.

PROJECT PROFILE:

In its continuing research of new structural highway construction technologies, the Texas Department of Transportation (TxDOT) has expanded its implementation of custom fiber-re-inforced polymer (FRP) composite bridge beams for a new drainage ditch bridge (FM-1684) in Refugio County, TX. The bridge is a replacement: of a single-span girder-bridge (50' long x 32' wide) that utilizes customized FRP flanged U-Shaped Beams (50' long x 30" deep) and a concrete deck construction.

Thirty-five miles from Corpus Christi, the Refugio County Bridge will be the state's second FRP hybrid-bridge endeavor—following the successful construction of the San Patricio County Bridge nearly three years ago. The county has a humid subtropical climate (averages thirty-seven inches of rain annually) which results in corrosive salt and brackish water. Therefore, although more costly upfront, TxDOT specified the FRP beams to advance the research of the long-term corrosion and structural performance benefits of FRP materials vs. traditional steel or concrete beam solutions.

With the FRP beams specified by TxDOT, General Contractor Haas-Anderson Construction (Corpus Christi, TX) enlisted Molded Fiber Glass Construction Products (MFG: Independence, KS), who had produced the previous FRP beams at San Patricio, to manufacture eight (8) customized flanged U-Shaped beams whose depth and composite structure would provide optimal deflection under load. Once completed, the beams would weigh approximately 5, 000 lbs. each and sit on abutments where the concrete deck would be poured onto it.

Beginning in late 2006 and scheduled for completion in summer 2007, the project's goal was to take the lessons learned from the previous bridge project and evolve the current customization and production processes in hopes of optimizing performance and cost variables for future projects.

FRP CHALLENGE/FORMING PROCESS:

MFG fabricated the beams in its Texas location utilizing a Vacuum Infusion Process (VIP) versus the previous project's hand lay-up to optimize the physical properties of the beam and facilitate production. This process was selected because vacuum infusion provided a number of benefits including; consistent fiber-to-resin ratio, less wasted resin, unlimited set-up time and much lower emissions. The VIP utilizes a vacuum bag to de-bulk or compact the parts' complete laminate ply schedule of reinforcements and or core materials that are laid onto the mold.

For the Refugio beams, a male mold was produced to the beam design and then dry sheets of stitched glass fabric and chopped strand mat were laid over the U-Shaped mold. This process was applied in a series of layers to achieve the appropriate 1.5" beam thickness, and then a plastic film was laid on top to serve as a vacuum bag. Once a complete vacuum was achieved, liquid resin was then introduced into the laminate via carefully placed tubing. The vacuum then draws the resin through the fibers, filling all the voids and eliminating any remaining air along the flow-front.

According to Rich LaFountain, MFG Business Unit Leader/Open Molding, "The trick is to get the bag to draw down correctly so that wrinkles don't develop in the individual layers of fabric which could affect the ultimate strength of the composite."

MATERIALS UTILIZED:

WOVEN FABRIC:

▲ 3-Tex Material— 77 oz. per square yard / 3WEAVE™ using PPG Roving / (3K lbs. per part)

CHOPPED STRAND MAT:

▲ Owens Corning OC® 1.5 oz. / (300 lbs. per part)

RESIN:

▲ AOC Vipel® — corrosion resistant vinyl ester resin / (1,700 lbs. per part)

Once completed, Robert Sarcinella, TxDOT Materials Brach Manager/Construction Division and his staff, went to MFG Texas to inspect the fabricated beams for approval and noted, "This project's production went as if it were on steroids…MFG took lessons learned from the first project and fabricated the beams more quickly and with better quality than before via their vacuum process."

ASSEMBLY/INSTALLATION:

Once completed, the beams were cured, trimmed and assembled with shear transfer members (brace bars) that included flange plates/tubes across every 16" in a 50' beam. Holes were drilled into the vertical sides and brace bars (2" diameter) were inserted through the beam at the top of the webs (lips) on either side. The beams were placed at 4'-0" center-to-center spacing with the concrete reinforced deck placed on top.

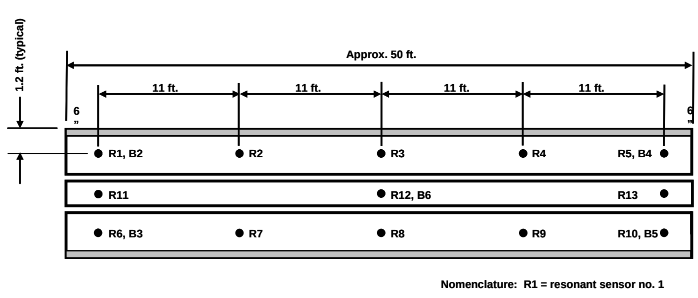
The deck was then tied to the beams with horizontal pipe (2.6" deep x 2.3" wide) close to the top of beams. The concrete deck pour was deep enough to engage the brace pipe for optimal strength to tie the beams to the deck. The goal was to achieve composite action between the beams and the deck; creating an inflecture-solid connection between the deck and beams.

ACOUSTIC EMISSION TESTING:

Prior to installation, in April 2007, Beam Nos. 1 and 2 were given the Acoustic Emission Evaluation Test by The University of Texas at Arlington's Guillermo Ramirez, PhD and Paul Ziehl PhD from the University of South Carolina. The tests monitored emission during the background check prior to loading, during load holds, and during the background check after completion of loading.

The test threshold was 40 dB and the evaluation threshold was 48 dB. The main sensors used were type R15I (resonant in the range of 150 kHz) manufactured by Physical Acoustics (PAC). Broadband sensors were used for supplemental evaluation. Activity from the R15I sensors was monitored and recorded with a 24-channel Transportation Instrument; also manufactured by PAC.

Approximate sensor locations for the reloading are shown in the figure below.



Sensor Locations (Beam No. 1 and Beam No. 2)

According to Dr. Ramirez, "The test verifies the performance of the beams under the load criteria set forth by the project specifications. The beams performed well during load testing— passing the major criteria selected for the Acoustic Emission test. In fact, the beams' stiffness tested better than expected substantiating their ability to sustain in service loads." Ramirez added, "The beams looked very nice, with no visible flaws. The method of fabrication resulted in a very good product."

RESULTS / CONCLUSION:

Roy Tijerina, Superintendent for Haas-Anderson Construction, assessed the short term benefits of the FRP beams stating, "They delivered all the FRP beams in one truck and handling and installation were easier; using a small crane or large track hoe vs. multiple cranes with steel or concrete options. This means minimal equipment and people are required; which equates to built-in time and cost efficiencies on the project." Tijerina concluded that, "In addition to the lightweight FRP beams allowing for rapid onsite deployment, its material strength over time will reduce maintenance costs on the overall construction of the bridge."

A post-construction assessment by TxDOT/Federal Highway Administration Division Bridge Engineer Peter Chang noted, "The funding to promote the new fiberglass girder technology was allocated by TxDOT as a research project. With the load testing calculated and installation complete, the beams are actually stronger than we anticipated, thus proving the research positive."

CORPORATE PROFILE:

MFG Construction Products Company, formed in 1962 and a charter member of the World of Concrete, manufactures a complete range of one-piece round column forms (RCFs), dome and pan forms for one-way and two-way joist slab floors, and customer forms for cast-in-place concrete construction applications. Made of fiberglass-reinforced thermo-set composites, MFG concrete forms can significantly reduce finishing costs and are fully re-usable.