DuraSpan®

fiber-reinforced polymer bridge deck systems

Martin Marietta Composites

Introducing

Route 418 over the Schroon River

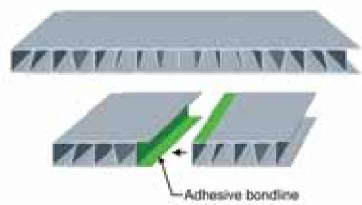
Warrensburg, New York

- Length: 161.31 feet
- Width: 25.17 feet
- Area: 4060 square feet
- Year Installed: 2000

The first U.S. truss bridge to utilize a FRP deck, this historic bridge was rehabilitated using a *DuraSpan 766* deck. The bridge has 4' longitudinal stringer spacing and 20' transverse floorbeam spacing. A FRP curb was pigmented and bonded to the deck to resemble timber curbs. The FRP deck was topped with a polymer concrete overlay.

Bridge Diagnostics, Inc. performed field load tests to verify the strength and durability of the composite deck. Results substantiated the deck's ability to achieve composite bending action with longitudinal beams.

What Are the Benefits of DuraSpan®?



Schematic of DuraSpan Deck Panel

Bridge owners and engineers have discovered the advantages *DuraSpan®* decks offer over bridge decks made of conventional materials. When compared to typically used materials, these FRP (fiber – reinforced polymer) bridge decks are:

- **Lower weight** — one-fifth the weight of a comparable concrete deck.
- **Resistant to corrosion and freeze/thaw cycles**, resulting in longer life expectancy and lower maintenance costs.
- **Rapidly installed** using light equipment, which substantially reduces construction time and labor costs.
- **Solid Surface** — capable of being topped with skid-resistant overlays.
- **Prefabricated** into 8'–10' wide panels using a high quality manufacturing and assembly process.
- **Capable of achieving composite action** — Bridge designers often utilize *DuraSpan* to achieve composite bending action with the bridge's beams, thereby increasing the beams' ability to resist bending and deflection.

DuraSpan decks are currently offered in two configurations:

	Depth	Weight	Typical Allowable Beam Spacing
DuraSpan 500	5.00" (127mm)	13 p.s.f. (.62 kN/m²)	5'-0" (1.52m)
DuraSpan 766	7.66" (195mm)	19 p.s.f. (.91 kN/m²)	10'-0" (3.05m)

Both decks support AASHTO HS25 live loadings (plus impact). Extensive laboratory and field load tests indicate that the ultimate capacities of both decks far exceed requirements.

Which Bridges Are Ideal for FRP?

With over two dozen installations in the U.S. and abroad, Martin Marietta Composites has faced a wide variety of applications. Composite materials have significant advantages over conventional materials (steel, wood and concrete) in those cases where light weight, corrosion resistance and rapid installation are important. As such, *DuraSpan* finds great applications in historic bridges, movable bridges and urban environments.

In many cases, FRP decks are the only means of preserving a historic or movable bridge while updating it to modern standards. *DuraSpan* can reduce dead load on the structure, possibly increasing its live load capacity. Like steel grating, *DuraSpan* has low weight and can be installed in modules. However, *DuraSpan* is a solid surface, corrosion resistant deck that offers improved skid resistance and is capable of developing composite action with the bridge's longitudinal beams.

Facing increasing pressure from the public to keep roads and bridges operational, bridge owners are seeking innovative materials and methods of construction. *DuraSpan* offers an excellent solution, particularly for time-critical, urban projects. It can often be installed in less time than conventional materials, reducing overall construction time and minimizing public impact.

DuraSpan

What Are FRP Composites?

FRP composite material is a combination of a polymer matrix (resin, fillers and additives) and a reinforcing agent (glass or carbon fabrics). These constituent elements retain their identities — that is, they do not dissolve or merge completely into one another — yet function like a single element.

What Are its Structural Characteristics?

FRP composites are anisotropic — meaning that the mechanical properties vary with the volume and orientation of the fiber reinforcement. Just as reinforcing steel can be placed in concrete for specific loads, the fiber components of composites can be oriented to meet specific design loads and performance requirements.

Design of FRP structures is typically driven by deflection requirements. With polymer composites in general, use of innovative geometry and optimal fiber orientations can enhance the stiffness. Martin Marietta Composites utilizes its patented deck tube design and fiber lay-ups to achieve optimal stiffness and cost effectiveness. Our well-balanced, quasi-isotropic fabrics yield a highly durable product.

Using a rule of thumb from the aerospace industry, Martin Marietta Composites typically limits design strains to 20% of ultimate capacity. Conservative deflection criteria often drive the design strains even lower than this 20% criterion. The end result is a product that possesses an extremely high safety factor for strength and sees negligible effects from fatigue and creep.

How is it Made?

DuraSpan products are manufactured through a strategic alliance with Creative Pultrusions, Inc., a world leader in structural composites. Martin Marietta Composites chose pultrusion as its manufacturing process because of its proven 30-year history. Pultrusion's automation and quality control make it the most cost-effective process in the business today.

The pultrusion process begins when continuous fibers and stitched engineered fabrics are drawn from creels and formed to the desired shape via a series of complex forming tools. The fabrics are then drawn through liquid polymer resin and a heated die at a specific speed and temperature to form the solid composite tube. A computerized translating saw then cuts the cured tubes to the desired lengths.

Individual pultruded tubes are sent to a fabrication facility, where they are assembled into panels using adhesive. Workers perform secondary processes such as hole cutting and sealing, installation of edge closeouts and surface finishing. The prefabricated panels are finally shipped to the job site for installation. The panel length equals the bridge deck width or staging width. Panel width typically equals 8' - 10' due to shipping constraints.

MD 24 over Deer Creek

Harford County, Maryland

- Length: 125.21 feet
- Width: 31.5 feet
- Area: 3944 square feet
- Year Installed: 2001

This historic bridge demonstrates the feasibility of staged construction with Martin Marietta Composites' FRP decks. This bridge has 4'-1" longitudinal stringer spacing, 24'-6" transverse floorbeam spacing and a severe skew of 146 degrees. The deck was overlaid with asphalt.

Monitoring and load testing was conducted by the University of Maryland.

Lewis and Clark Bascule Bridge

Clatsop County, Oregon
- Length: 113.66 feet
- Width: 20.51 feet
- Area: 2331 square feet
- Year Installed: 2001

This was the first movable bridge in the U.S. to utilize a FRP deck. The historic bridge was rehabilitated using Martin Marietta Composites' *DuraSpan 766* deck. It has 2'-9 1/2" longitudinal stringer spacing and 16'-0" transverse floorbeam spacing. A FRP curb was pigmented and bonded to the deck to resemble timber curbs. The composite deck was topped with a polymer concrete overlay.

Old Young's Bay Bascule Bridge

Clatsop County, Oregon
- Length: 159.69 feet, Width: 20.51 feet
- Area: 3275 square feet
- Year Installed: 2002

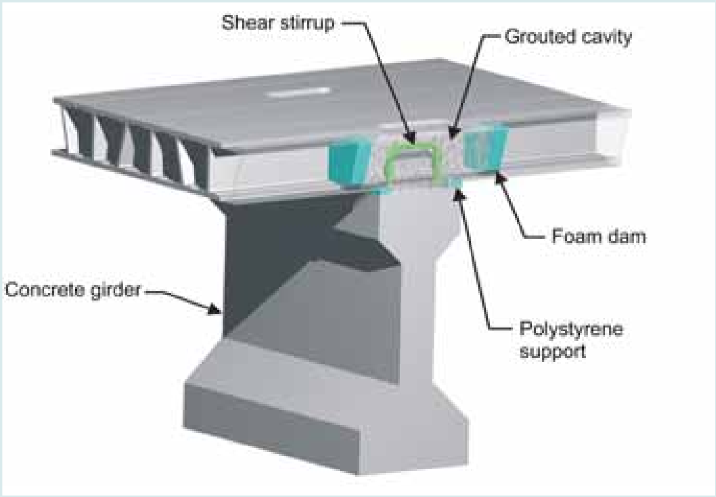
This historic double leaf trunnion bascule bridge used Martin Marietta Composites' *DuraSpan 766* deck to preserve its steel truss. The bridge has 5'-0" longitudinal stringer spacing and 15'-8" transverse floorbeam spacing. A FRP curb was pigmented and bonded to the deck to resemble timber curbs. This deck was topped with a polymer concrete overlay.

Deck-to-Girder Connections

DuraSpan decks have been installed on steel, concrete, timber and FRP girders. The majority of *DuraSpan* decks achieve composite bending action with the girders via conventional shear studs/stirrups and grouted deck cavities. These connections have a proven history with broad acceptance by bridge engineers and contractors. In addition, all work is performed from above. These deck-to-girder connections have endured rigorous static and fatigue tests in both horizontal shear and transverse bending.

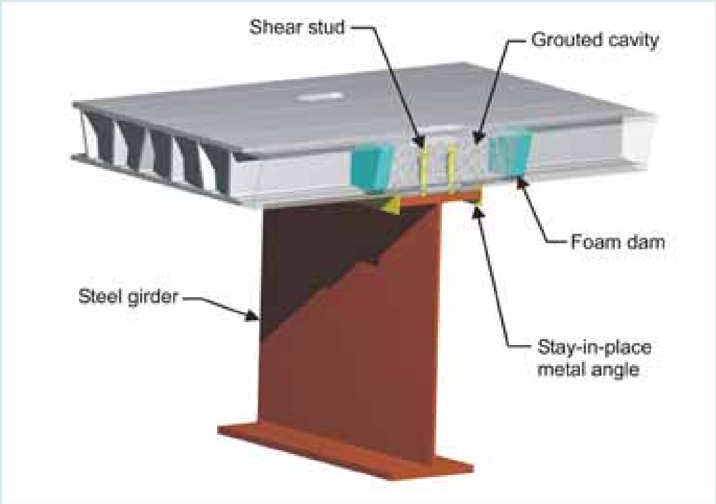
Depending on site conditions, other methods of attachment are available, including mechanical fasteners. However, as with most concrete decks, variable haunches (build-ups) are usually required to adjust for cross-slopes on the roadway, camber in the beams or variations in the top of beam elevations. As such, the shear stud/stirrup connection described above is most common.

Concrete Girders



Concrete girders utilize conventional shear stirrups to achieve composite bending action with FRP decks.

Steel Girders



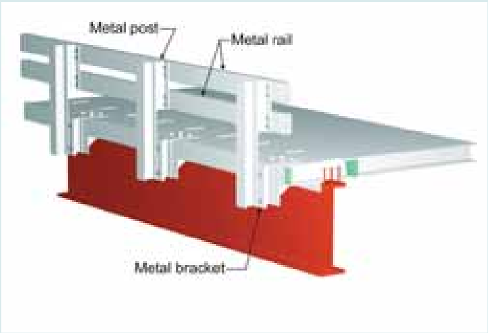
Steel beams utilize conventional shear studs to achieve composite bending action with beams.

Details

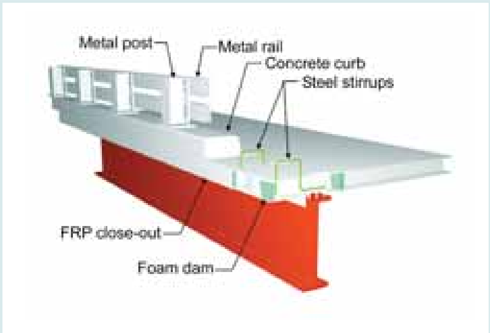
Railing Details

A variety of railings have been utilized with *DuraSpan* decks. Owners may choose from their own list of pre-approved concrete, steel, or timber designs. Martin Marietta Composites can accommodate many railing configurations.

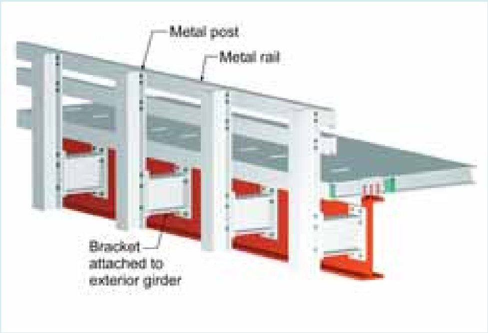
A concrete barrier or curb can be connected to *DuraSpan* decks by embedding reinforcing steel into the deck's grouted cavities. If steel guardrails are desired, the base plates for the posts can be bolted directly to the deck, or anchor bolts can be embedded into a closed cavity in the deck and filled with non-shrink grout. Steel railings may also cantilever from the bridge's exterior beams.



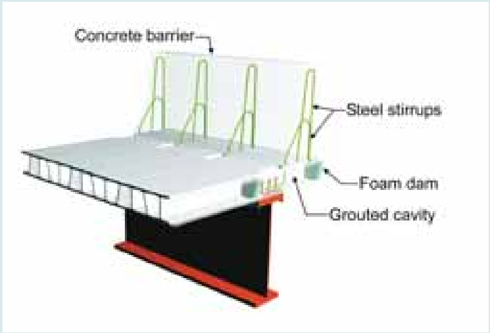
Railing Attached to Deck



Railing with concrete curb



Railing cantilevered from girders

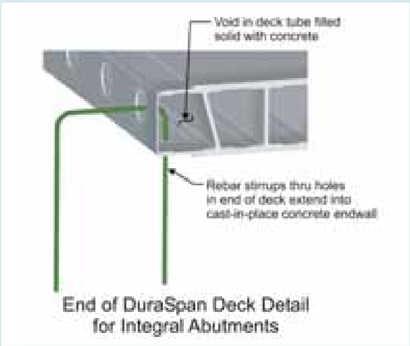


Concrete barrier attached to deck

Abutments and Expansion Joints

Like railings and overlays, abutment and expansion joint designs are chosen by the engineer and owner to best suit the project requirements. Integral and semi-integral abutments are preferable and can be integrated with the FRP deck via U-shaped reinforcing bars. Where expansion allowance is required, compressible foam joints have performed quite well.

U-shaped steel stirrups integrate deck with abutment



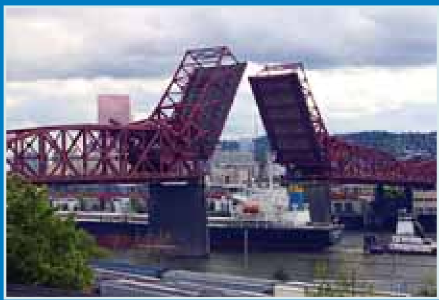
Schuyler Heim Lift Bridge

Long Beach, California

- Length: 45 feet
- Width: 35 feet
- Area: 1575 square feet
- Year Installed: 2003

Martin Marietta Composites was selected for this project over four international firms to design FRP test panels. This bridge has a custom 5-inch thick deck and is arranged in 8 panels measuring 6' by 36'. It has 4' longitudinal stringer spacing and 24' transverse floorbeam spacing. 3/4" diameter threaded shear studs were used for the deck-to-stringer connections. The overlay is 3/8" polymer concrete. Adjacent to Long Beach's port, an extensive testing program is planned to monitor this heavily traveled bridge.

Testing and



Broadway Bridge

Portland, Oregon

- Length: 258.35 feet
- Width: 46.33 feet
- Area: 11970 square feet
- Year Installed: 2004

The Broadway Bridge over the Willamette River is in the heart of the Portland harbor and is a vital structure to the surrounding areas. The historic bridge carries four lanes of traffic with an average daily volume of 30,000 vehicles. Originally constructed in 1913, the bridge is the largest of only three Rall bascule bridges remaining in the United States. According to the bridge's owner, the Broadway Bridge is the seventh longest bascule bridge in the world. Due to safety and maintenance issues, the worn steel grid deck on the bascule spans was replaced with the DuraSpan 500 FRP deck as a part of an overall $26.2 million rehabilitation project. A solid-surface, light weight deck that could be rapidly installed made DuraSpan the preferred decking material. The Broadway Bridge is one of the largest and most frequently traveled FRP vehicular bridge decks in the world.

Testing

Martin Marietta Composites' FRP bridge decks have been thoroughly tested in both laboratory and field settings. Labs across the United States have rigorously tested the static and fatigue performance of the panel and its connections. Static tests typically indicate an extremely high factor of safety for strength, while fatigue tests show little to no degradation after millions of load cycles. Field load tests commonly verify in-place performance and validate the initial design assumptions. From coupon tests through full-scale multi-beam assemblies, results consistently reflect *DuraSpan's* high strength, durability and its tendency to meet or exceed project requirements.

DuraSpan transverse bending test — North Carolina State University

Two million cycle fatigue and static test — University of California at San Diego

Effective width/composite action test — University of Pittsburgh

DuraSpan flexural response and damage tolerance — Lehigh University

Field load testing — Union County, North Carolina

Field load testing — Greene County, Ohio

Installation

Installation

Adhesive applied at field joint

Panels set into place

Jacking panels

DuraSpan's light weight and design flexibility allow panels to be delivered to the jobsite in large, pre-fabricated modules. Once they arrive, the panels are ready to be installed by maintenance forces or licensed contractors. Martin Marietta Composites typically works closely with construction crews, providing detailed installation manuals to help transition the installation team to this new material.

The installation process:

- Apply adhesive to panel's tongue and groove field joints.
- Set panel on beam haunches with crane or forklift.
- Jack panels together with light duty jacks.
- Once several panels have been installed and bond lines have cured, workers install a field splice strip over each field joint.

After FRP deck installation is complete, shear connections are attached to beams and certain deck cavities are filled with grout. Finally, the overlay is placed.

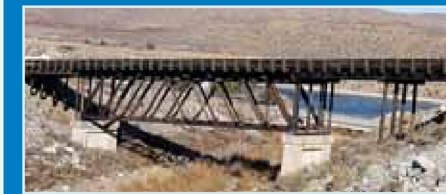
DuraSpan's pre-fabricated design speeds up construction and decreases its impact on the traveling public.

Splice strips installed over field joints

Overlay applied

Overlay

A variety of overlays have been utilized on *DuraSpan* bridge decks. Owners select these overlays based upon their project's requirements. Previous selections include polymer concrete, conventional asphalt, polymer-modified asphalt and micro silica-modified concrete. On weight-critical structures (like movable and historic bridges), owners often select polymer concrete for its thin lift capabilities.

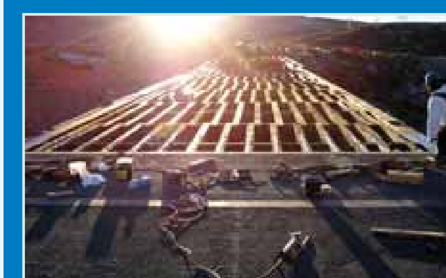


Chief Joseph Dam Bridge

Douglas County, Washington

- Length: 309.6 feet
- Width: 32 feet
- Area: 9907 square feet
- Year Installed: 2003

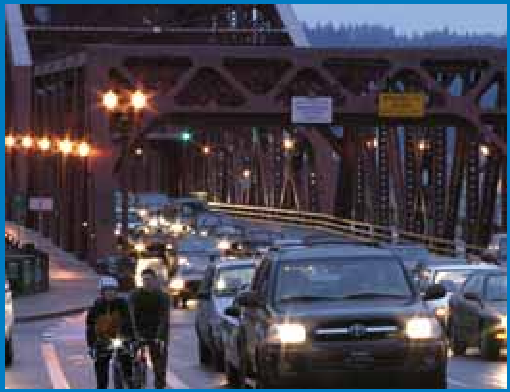
The Chief Joseph Dam Bridge utilizes glulam beams in its approach spans and a historic timber truss in its main span. A new FRP deck was installed in late 2003 and was Martin Marietta Composites' first bridge to utilize timber beams. *DuraSpan* allowed preservation of this historic truss, of which only a few of its type still exist. The FRP deck also widened the bridge by six feet to accommodate modern traffic lanes. The *DuraSpan* deck was pigmented to match the existing timber truss and the deck was covered with an asphalt overlay.



Martin Marietta Composites is a subsidiary of Martin Marietta Materials, Incorporated (NYSE:MLM), the nation's second largest producer of construction aggregates. Development of the *DuraSpan* deck system began in late 1992 at the Lockheed Martin Missile and Space Division's Palo Alto Research and Development Laboratory, where composite technology was applied to aerospace and transportation industries.

In 1995, Martin Marietta Materials acquired the technology and established Martin Marietta Composites. Headquartered in Raleigh, North Carolina, Martin Marietta Composites develops and markets composite products to the construction, infrastructure and transportation industries.

At Martin Marietta Composites, we understand introducing a new material requires support and teamwork. We are committed to providing support and expertise to assist our customers' transition from traditional materials to composites. Our services include finite element modeling (where needed), a technical staff with both FRP and bridge expertise, extensive FRP resources, and on-site field personnel to assist during installation. Numerous DOTs, engineering consulting firms and contractors substantiate Martin Marietta Composites' reputation for high quality products and services.



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It's not just what we make, it's what we make possible®

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