

Prefabricated Bridge Specifications Allowable Stress Design (ASD)

1.0 GENERAL

1.1 Scope

These specifications are for a fully engineered clear span bridge of Fiber Reinforced Polymer (FRP) composite construction and shall be regarded as the minimum standards for design and construction. The FRP structure shall be manufactured by Creative Pultrusions, Inc. (CPI), 214 Industrial Lane, Alum Bank, PA, phone 814-839-4186 (Toll-free 888-274-7855), or approved equal.

1.2 Qualified Suppliers

The FRP bridge manufacturer shall be an ISO 9001:2015 accredited company for the design and manufacture of FRP structural components and systems. The company shall have been in the business of design and fabrication of bridges for a minimum of ten years. Company shall provide a list of five successful bridge projects, of similar construction, each of which has been in service at least three years. List the location, bridge size, owner and contact reference for each bridge.

2.0 GENERAL FEATURES OF DESIGN

2.1 Span

Bridge span will be xxx' xx" (straight line dimension) and shall be measured from each end of the bridge structure.

2.2 Width

Bridge width shall be xx' xx" and shall be measured from the inside face of structural elements at deck level.

2.3 Bridge System Type

Bridges must be designed as a FRP Composite Truss Span.

2.4 Member Components

All members shall be fabricated from pultruded FRP composite profiles and structural shapes as required.

2.5 Camber

Bridges to be precambered to eliminate initial dead load deflection.

3.0 ENGINEERING

Structural design of the bridge structure(s) shall be performed by or under the direct supervision of a Licensed Professional Engineer and done in accordance with recognized engineering practices and principles.

3.1 Uniform Live Load

All bridge spans to be designed for 85 psf.

3.2 Vehicle Load (as required)

A specified vehicle configuration determined by the Operating Agency may be used for the design vehicle. If an Agency design vehicle is not specified, the loads conforming to a light weight vehicle of 10,000 lbs is used. A 4'x4' wheel base is assumed. Wheel loads are distributed as 4 equal concentrated point loads unless otherwise specified. The maintenance vehicle live load shall not be placed in combination with the pedestrian live load. A vehicle impact allowance is not required.

3.0 ENGINEERING (cont'd)

3.3 Wind Load

All bridges shall be designed for a minimum wind load of 25 psf. The wind is calculated on the entire vertical surface of the bridge as if fully enclosed.

3.4 Seismic Load

Seismic loads shall be determined according to the criteria specified in the standard building codes (IBC, ASCE, or UBC) unless otherwise requested. Response Spectrum Analysis shall be performed in those designs that require complex seismic investigation. All necessary response spectra information will be provided by the client for evaluation.

3.5 Design Approach

An Allowable Stress Design (ASD) approach is used for the design of all structural members. Factors of safety used by CPI in the design of FRP bridges are as follows unless otherwise specified: (Based on the Ultimate Strength of the FRP material):

| | |
|-------------|-----|
| Tension | 2.5 |
| Compression | 2.5 |
| Shear | 2.5 |
| Bending | 2.5 |
| End Bearing | 2.5 |
| Connections | 3.0 |

Above information is based on E.T. Techtonics 5 year test program funded by the National Science Foundation.

3.6 Serviceability Criteria

Service loads are used for the design of all structural members when addressing deflection and vibration issues. Criteria used by CPI in the design of FRP bridges are as follows:

Deflection:

$$\text{Live Load (LL) deflection} = L/240$$

$$\text{Vertical Frequency (fn):} = 5.0 \text{ Hz}$$

The fundamental frequency of the pedestrian bridge (in the vertical direction) without live load should be greater than 5.0 hertz (Hz) to avoid any issues with the first and second harmonics.

$$\text{Horizontal Frequency (fn):} = 3.0 \text{ Hz}$$

The fundamental frequency of the pedestrian bridge (in the horizontal direction) without live load should be greater than 3.0 hertz (Hz) to avoid any issues due to side to side motion involving the first and second harmonics.

3.7 Snow Load

Sustained snow load conditions shall be evaluated for time dependent effects (creep and relaxation) and expected recovery behavior.

4.0 MATERIALS

4.1 FRP Composites

FRP bridges shall be fabricated from high-strength E-glass and isophthalic polyester resin unless otherwise specified. Weathering and ultraviolet light protection shall be provided by addition of a veil to the laminate construction. Minimum characteristic design strengths, per ASTM D7290 are as follows:

| | CH662 | CH860 | TQ240 | |
|----------------------------|--------------|--------------|--------------|--|
| Tension (LW) (psi) | 67,236 | 59,150 | 63,968 | ASTM D638 |
| Compression (LW) (psi) | 71,285 | 70,888 | 43,363 | ASTM D6641 |
| Shear (In-plane) (psi) | 9,954 | 9,773 | 9,977 | ASTM D5379 |
| Shear (interlaminar) (psi) | 4,442 | 3,969 | 4,189 | ASTM D2344 |
| | | | | ASTM D6641 & D638 |
| Young's Modulus (LW) (psi) | 4.35E+06 | 4.41E+06 | 3.87E+06 | (Taken as the mean of the lessor of the two) |

The minimum thickness of FRP composite shapes shall be as follows unless otherwise specified: square tube members (closed type shape) shall be 0.25 in. wide-flange beams, channel sections, and angles (open type shapes) shall be a minimum thickness of 0.25 in. standard plate shall be a minimum thickness of 0.25 in.

4.2 Decking FRP Connections

All FRP bridge connections shall be classified as concentric bolt bearing & contain at least (2) bolts for load transfer.

All connections shall be experimentally determined via full section joint component testing.

- Tubes/solids shall be investigated @ 0-deg. with 3/4" A307 bolts
- Channels shall be investigated @ 0,45,90-deg. with 3/4" A307 bolts
- Channels shall be investigated @ 45,90 -deg. with 3/8" plate & 3/4" A325 bolts
- All tube/solid capacities shall utilize a tube with bonded solid plug in the bearing area
- All channel capacities shall utilize (2) channels
- Tests with plates shall use a section of channel as the doubler plate in the bearing area
- All capacities shall be measured utilizing (2) bolts except CH860 0 -deg. (3 bolts)

The FRP bridge manufacturer shall provide test data showing the joint configurations achieve all stipulated characteristic values when analyzed in accordance with ASTM D7290.

The minimum allowable characteristic values are as follows:

| Component / Orientation | Characteristic Value |
|---|-----------------------------|
| TQ240/SQ024 @ 0 -deg. (Compression) | 73,433 lbs. |
| TQ240/SQ024 @ 0 -deg. (Tension) | 29,186 lbs. |
| CH662 @ 0 - deg. (Tension) | 33,886 lbs. |
| CH662 @ 90 - deg. (Tension) | 33,253 lbs. |
| CH662 @ 90 - deg. w/ 3/8" Plate (Tension) | 51,094 lbs. |
| CH662 @ 45 - deg. (Tension & Compression) | 36,018 lbs. |
| CH662 @ 45 - deg. w/ 3/8" Plate (Tension & Compression) | 65,810 lbs. |
| CH860 @ 0 - deg. (Tension) | 50,151 lbs. |
| CH860 @ 90 - deg. (Tension) | 30,439 lbs. |
| CH860 @ 90 - deg. w/ 3/8" Plate (Tension) | 53,981 lbs. |
| CH860 @ 45 - deg. (Tension) | 39,247 lbs. |
| CH860 @ 45 - deg. w/ 3/8" Plate (Tension) | 72,439 lbs. |
| CH860 @ 45 - deg. (Compression) | 48,886 lbs. |
| CH860 @ 45 - deg. w/ 3/8" Plate (Compression) | 62,308 lbs. |

1 TQ240 = 2"x2"x1/4" Tube SQ024 = 1.5"x1.5"x.5" Solid
 CH662 = 6"x1-11/16"x3/8" Channel CH860 = 8"x2-3/16"x3/8" Channel

4.0 MATERIALS (cont'd)

4.3 Decking

Wood decking is No. 2 Southern Yellow Pine treated according to the American Wood Preservers Bureau. Standard 3 in. x 12 in. (nominal) planks can be provided for equestrian and light vehicle type loading conditions as required. High strength fiberglass decking can also be provided as required.

4.4 Hardware

Bolted connections shall be A307 hot-dipped galvanized steel unless otherwise specified. Mounting devices shall be galvanized or stainless steel.

5.0 SUBMITTALS

5.1 Submittal Drawings

Schematic drawings and diagrams shall be submitted to the client for their review after receipt of order. As required, all drawings shall be signed and sealed by a licensed Professional Engineer.

5.2 Submittal Calculations

As required, structural calculations shall be submitted to the client. All calculations will be signed and sealed by a licensed Professional Engineer.

6.0 FABRICATION

6.1 Tolerances

All cutting and drilling fabrication to be done by experienced fiberglass workers using carbide or diamond-tipped tooling to a tolerance of 1/16" per the Code of Standard Practice, Industry Guidelines for Fabrication and Installation of Pultruded FRP Structures, 2012. No material deviations beyond industry standards are accepted. All cut edges to be cleaned and sealed.

6.2 Profile Tolerances

Pultruded profiles shall be manufactured to the dimensional requirements as set forth in ASTM D3917 and the visual requirements as set forth in ASTM D4385.

7.0 RAILINGS

7.1 Railings

Railings should be a minimum of 42" above the floor deck for pedestrian and bicycle use and should be a minimum of 54" above the floor deck for equestrian use.

7.2 Safety Rails

Continuous horizontal safety rails of 3" channel shall be located on the inside of the trusses. Maximum opening between the safety rails shall be available as required, but should not be greater than 4". If preferred, vertical pickets can be provided upon request.

7.3 Toeplates (optional)

Continuous horizontal toe plates of 3" channel shall be located on the inside of the trusses near deck level.

8.0 FINISHING

Bridge color shall be determined by the client. No painting is required as the color is added during the manufacturing process. Green is recommended for park and trail bridge applications. Custom colors can be provided upon request.

9.0 DELIVERY AND ERECTION

Delivery is made by truck to a location nearest the site accessible by roads. The bridge manufacturer will notify the client in advance of the expected time of arrival at the site. Bridges are usually shipped to the site in component parts or partially assembled depending on site requirements. The spans can then be completely assembled using standard hand tools. Upon request, bridges can also be shipped totally assembled to the site. Unloading, splicing (if required) and placement of the bridge will be the responsibility of the client.

9.1 Erection Direction

For bridges shipped in component parts or partially assembled, the bridge manufacturer shall provide assembly drawings and a recommended assembly procedure for building the bridge. Temporary supports or rigging equipment, if needed, is the responsibility of the client. For bridges shipped assembled, the bridge manufacturer shall advise the client of the actual lifting weights, attachment points and all necessary information to install the bridge.

9.2 Site Issues and Foundation Design

The client shall procure all necessary information about the site and soil conditions. Soil tests shall be procured by the client. The engineering design and construction of the bridge abutments, piers and/or footing shall be by the client. The bridge manufacturer will provide the necessary information pertaining to the bridge support reactions. The client shall install the anchor bolts in accordance with the bridge manufacturer's anchor bolt spacing dimensions.

10.0 WARRANTY

The bridge manufacturer shall warrant the structural integrity of all FRP materials, design and workmanship for 15 years. This warranty shall not cover defects in the bridge caused by foundation failures, abuse, misuse, overloading, accident, faulty construction or alteration, or other cause not the result of defective materials or workmanship. This warranty shall be limited to the repair or replacement of structural defects, and shall not include liability for consequential or incidental damages.