STRONGWELL

BRIDGE COMPONENTS

FIBER REINFORCED POLYMER COMPOSITES

INTRODUCTION

Strongwell is the world's leading pultruder of fiber reinforced polymer (FRP) structural shapes. The company's FRP composite products have been used since 1956 to solve problems for customers in a wide variety of markets, some of which are shown below. Strongwell's in-house staff of registered professional engineers represents nearly every engineering discipline, including structural engineering. The company also has complete fabrication facilities and the largest production capacity in the industry to ensure that customer needs are satisfied quickly and completely.

FRP BRIDGE GIRDERS

36" x 18" EXTREN DWB® designed for use in vehicular bridges.

Strongwell operates three ISO-9001 certified pultrusion plants. The company's primary focus is the manufacture of fiber reinforced polymer (FRP) structural shapes, grating, handrail and building products.

Since 1995, Strongwell has focused its design engineering and manufacturing resources on the development of FRP products for vehicular bridges. The two main products developed are a 36" x 18" double web beam and a fabricated FRP tube and plate bridge deck panel. Each of these products has undergone extensive laboratory testing as well as field demonstration testing.

The Virginia Department of Transportation chose the 36" x 18" EXTREN DWB® to construct a 38' bridge in Sugar Grove, Virginia.

36" x 18" EXTREN DWB® PROPERTIES

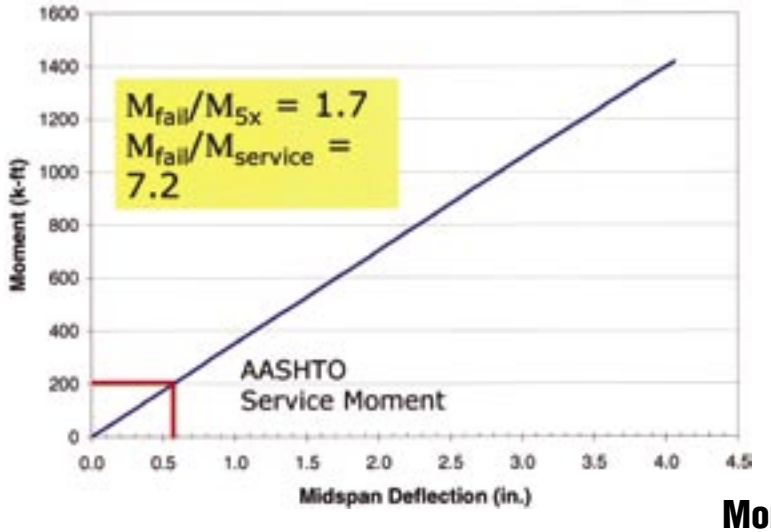
The primary features of the 36" x 18" EXTREN DWB® that are beneficial to bridge construction are:

- High strength-to-weight ratio
- Corrosion resistance
- Extremely stable — reduces the number of diaphragms
- Dimensional stability
- Low conductivity — thermally and electrically

The 36" x 18" EXTREN DWB® is a uniquely designed FRP structural shape incorporating traditional fiberglass rovings, continuous strand mat, 0°, 90° and ±45° stitched fabrics and carbon fiber tows. The carbon fiber tows are located in the top and bottom flanges for increased stiffness. The stitched fabrics are located in the webs and internal stiffeners for improved torsional resistance and shear.

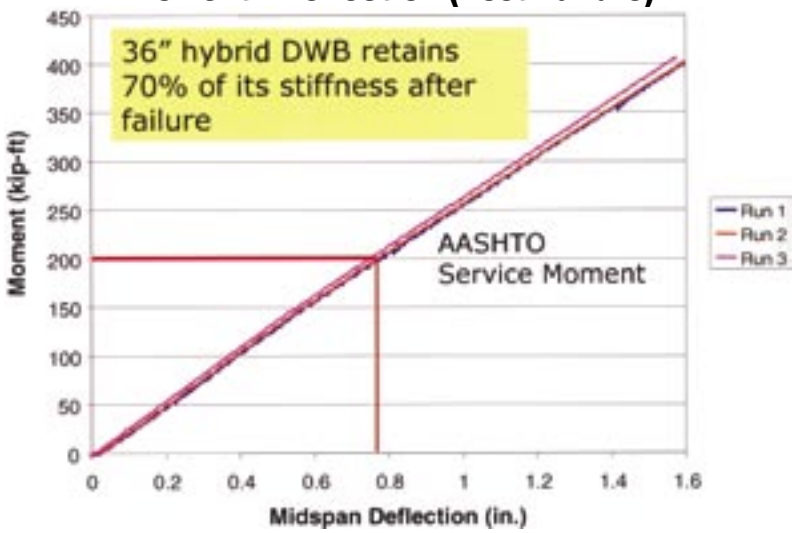
The 36" x 18" EXTREN DWB® has a modulus of elasticity of 6.0 msi versus a modulus of elasticity of 2.6 msi for traditional FRP structural shapes. The double web shape provides excellent stability with torsional rotation less than 1/2% in three point laboratory loading.

Moment - Deflection to Failure



36" x 18" DWB® safety factors are significantly greater than normally required for traditional materials.

Moment - Deflection (Post Failure)



The 36" x 18" EXTREN DWB® was installed in a Federal Highway Administration (FHWA) sponsored demonstration bridge project as part of the Innovative Bridge Research and Construction Program (IBRC) in September 2001. University professors from Virginia Tech performed a series of tests on the 36" x 18" EXTREN DWB® including stiffness testing of each beam. Eight beams were selected for the 38' span AASHTO HS-20 bridge located on Route 601 in Sugar Grove, Virginia.

Individual Testing Of Each Beam For Sugar Grove Bridge Project

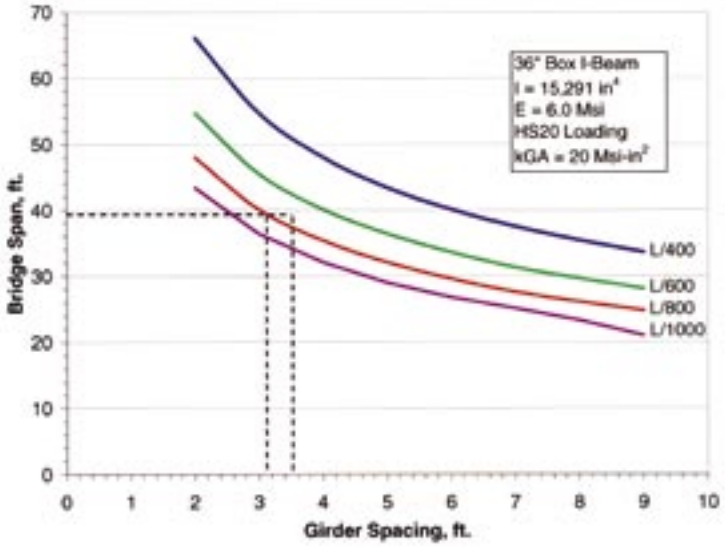
Beam #	Strongwell I.D. (Msi)	E (Msi-in²)	KGA (Msi)	E_{eff} service loading	Strain at service loading*	Ratio of strain to ultimate strain
1	2	6.45	24.3	5.49	431	14%
2	8	6.35	23.1	5.38	433	14%
3	19	6.05	24.8	5.21	459	14%
4	21	6.06	25.0	5.23	456	14%
5	23	5.88	30.7	5.22	475	15%
6	11	6.18	26.2	5.35	446	14%
7	10	6.20	34.1	5.54	445	14%
8	4	6.59	25.2	5.62	422	13%

Weibull Mean: 6.21 ± 0.27 ---- 5.27 ± 0.19

•Ultimate strain = 3170 me (top flange)
•Max moment = 1415 kip-ft comes from 1 test on beam #13

Conservative Properties Assumed In Design

E=6Msi & kGA = 20 Msi•in²



The bridge was designed based upon stiffness of 36" x 18" DWB®. Beam strength much greater than normal design requirements.

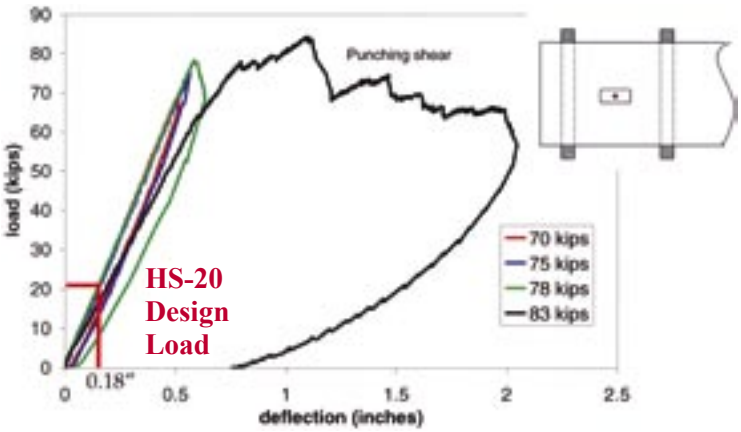
FRP BRIDGE DECK

Strongwell manufactures a vehicular bridge deck by combining pultruded square tubes and pultruded plate. The deck system can be designed for optimum performance depending upon design loads and stringer spacing. Tube sizes are typically 4" x 1/4" or 6" x 3/8" and plate thickness is typically 3/8" thick. The deck system comes complete with fastening hardware to allow positive attachment to steel, concrete or FRP bridge stringers.

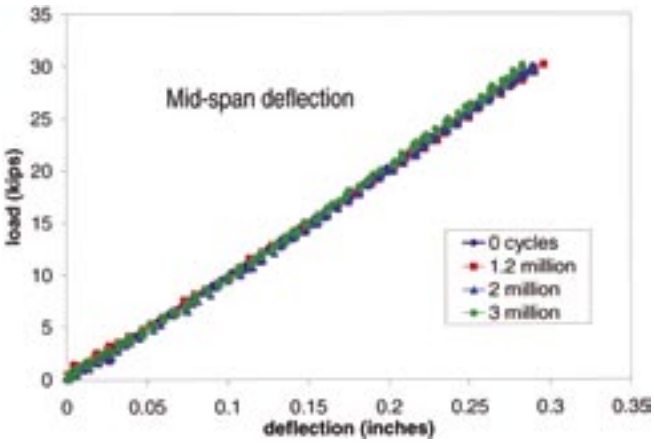
Load testing of Strongwell's FRP bridge deck indicates superior strength in AASHTO HS-20 or HS-25 bridge deck design requirements. Design safety factors approaching four (4) are obtained for Strongwell's bridge deck system.

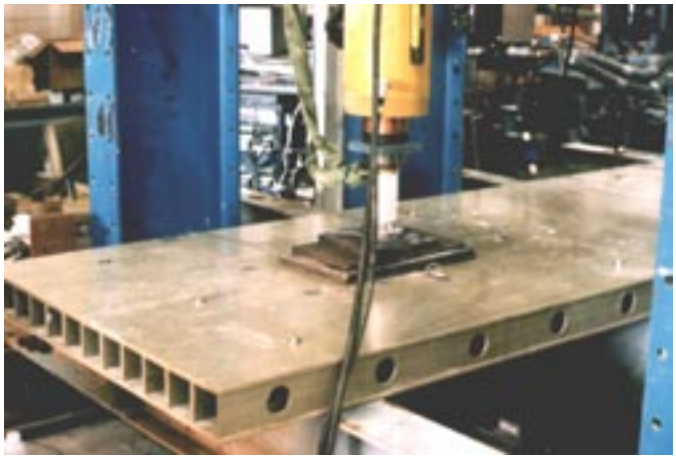
Strongwell's bridge deck has been fatigue tested at 30 kips for three million cycles with no loss of strength.

As-Fabricated Strength

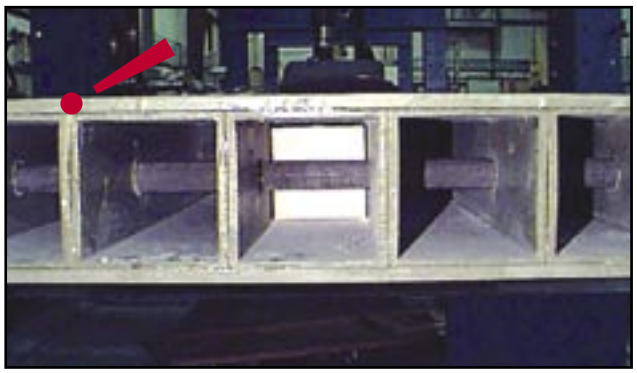


Fatigue: Stiffness Reduction vs. Cycles





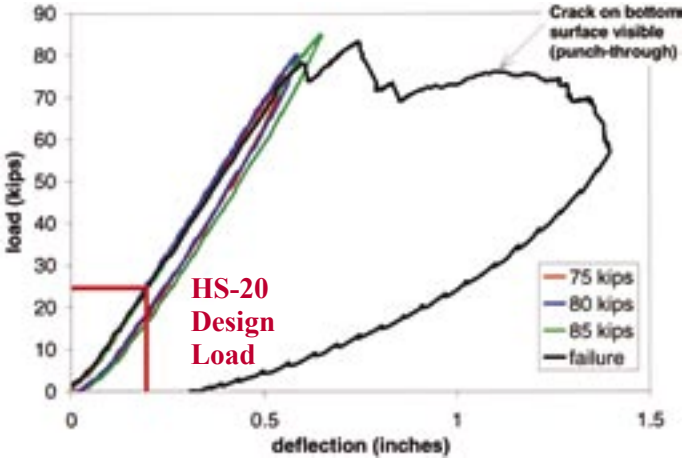
Steel Rods



EXTREN® Series 500 4" x 4" x 1/4" square tubes sandwiched between EXTREN® Series 500 3/8" plate.

Remaining Strength After Fatigue

(3 million cycles)



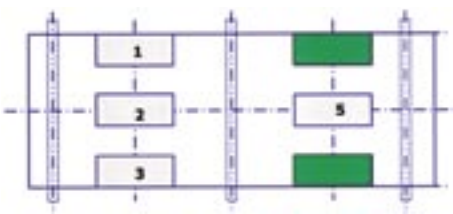
Laboratory testing shows virtually no loss of stiffness or strength after 3,000,000 cycles of loading.

Field testing of the Strongwell deck in a truck weigh station near Troutville, Virginia, showed no signs of deterioration after 1,200,000 trucks. The second FRP deck at the Troutville test bed was subjected to 5,000,000 trucks before its removal in December 2002. Each truck represents three loading cycles.

Deck Post Service Test After 1,200,000 Trucks

Deck #2: FEA Comparison with Experimental Results - Deflections

Loads	Experimental Results	FEM Results	Differences (%)
HS20, 5	L/517	L/513	0.7
HS25, 5	L/431	L/413	4.4
HS20, 4 & 6	L/328	L/311	5.5
HS25, 4 & 6	L/268	L/248	8.2
HS20, 2 & 5	L/605	L/605	0.0
HS25, 2 & 5	L/473	L/484	-2.4



Loading configuration and load amplitude

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