

# Bridge By Backhoe

Defiance County's Recent  
FHWA Funded Innovative  
Bridge Research and  
Construction Project

# Background and History

Defiance County is in Flat Northwest Ohio

Typical 100 Yr Velocities of 3-7fps

Typical Downstream Channel Slopes of 0.3% to  
0.05%

# 2000-2005 Bridge Replacements

- 24 Reinforced Concrete Boxes
- 23 Reinforced Concrete Pipes (Round and Elliptical)
- 10 Prestressed Conc. Box Beams on Capped Pile Abut.
- 6 Metal Pipes (Round and Elliptical)
- 3 Metal Boxes
- 1 Prestressed I Multispan
- 1 Concrete Slab
  
- 12 by Contract and 56 by Force Account

# Challenges

- Crane Costs and Clearances
- Structure Lengths and Headwalls
- Channel Closure Time
- Force Account Limits
- Cost

# Attempted solutions

- Cast in Place Headwalls
- Precast gravity Headwalls
- GRS Headwalls







07/11/2005

# GRS Wingwalls and Headwalls

- 7 Structures-5 boxes, 1 circular pipe, and 1 elliptical pipe
- Saved \$46,000 in precast purchases (Avg. \$6,600 per job) - 29%



# GRS – What is it?

Geosynthetically Reinforced Soil – Think of it as an internally stable gravity wall.

Close reinforcement spacing (8” or less) with well compacted select granular material

Supports Service Loads of ~2 tons per square foot

See NCHRP Report 556 for more information

# Cut away of GRS mass



# GRS abutments – Why?

Wall abutments reduce span length compared to spill through slopes.

Can be built and loaded quickly (2-3 Days)

Can be constructed without obstructing active channel

Very modular, can work around utilities, and adjust to a wide variety of skews and wingwall angles

Similar to lower cost vs. conventional abutments

# Bowman Rd - 80' span- 2005



# Glenburg Rd - 50' span- 2006



# Glenburg Rd – high water



# Behnfeldt Rd – 54' span-2006



09/20/2006

# Scott Rd-18' span 2007



# Bridge with a backhoe concept

- GRS abutments can be built with small equipment and hand labor.
- GRS is made of gravel and polypropylene fabric which both have extremely long life (100yr+)
  - FRP offers low weight superstructure that could be placed with similar equipment and have similar life to GRS

# Frustrations with FRP

- All Proprietary Systems, no apples to apples competition in traditional design-bid-build process.
  - Extremely high cost
- No way around explanation “of course the first bridge is expensive but if we could build 10 the cost would come down”

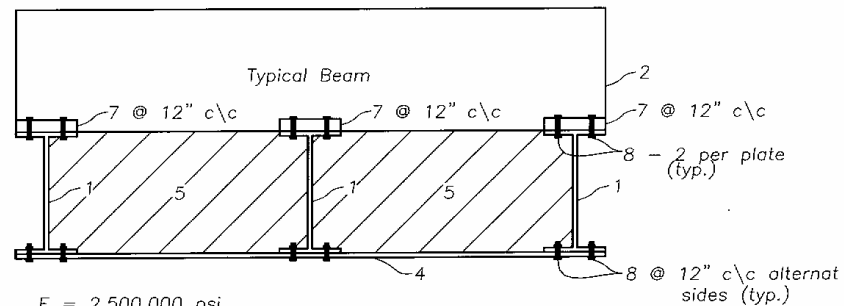
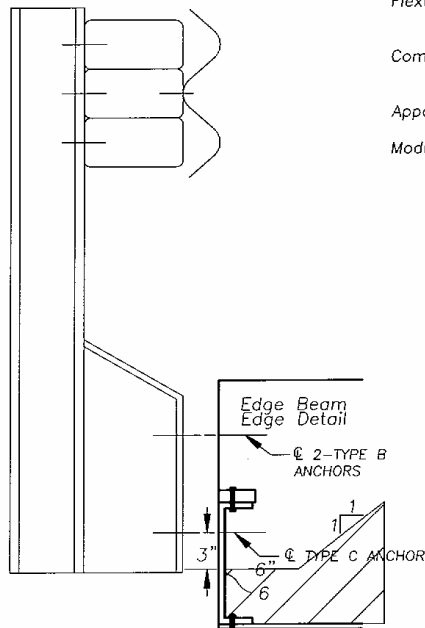
# Casebeer-Miller Rd Bridge

## Specification for Pultruded Structural Shapes

Pultruded shapes shall meet the tolerances of ASTM D3917

Pultruded shapes shall be free from defects as per ASTM D4385

Property	Test Method	Minimum
Tensile Strength	D638	30,000 psi Lengthwise 6,500 psi Crosswise
Tensile Modulus	D638	2.3x10 <sup>6</sup> psi Lengthwise 0.8x10 <sup>6</sup> psi Crosswise
Flexural Strength	D790	30,000 psi Lengthwise 10,000 psi Crosswise
Compressive Strength	D695	30,000 psi Lengthwise 10,000 psi Crosswise
Apparent Horizontal Shear	D2344	4,500 psi Lengthwise
Modulus of Elasticity		2,500,000 psi



1. 10"x5"x0.5" FRP I Beam
2. 48"x10" (9" Effective) Concrete Deck  
Lightweight Concrete
4. 0.375"x48" FRP Plate
5. Foam filler
6. 10"x2 3/4"x0.5" FRP Channel
7. 5"x6"x1" FRP Shear Plate (5"x48"x1" Plate every 6') 3"x6" on Channels
8. 3/8"x1 1/2" Stainless Steel Bolt, with nut and washers as clamp

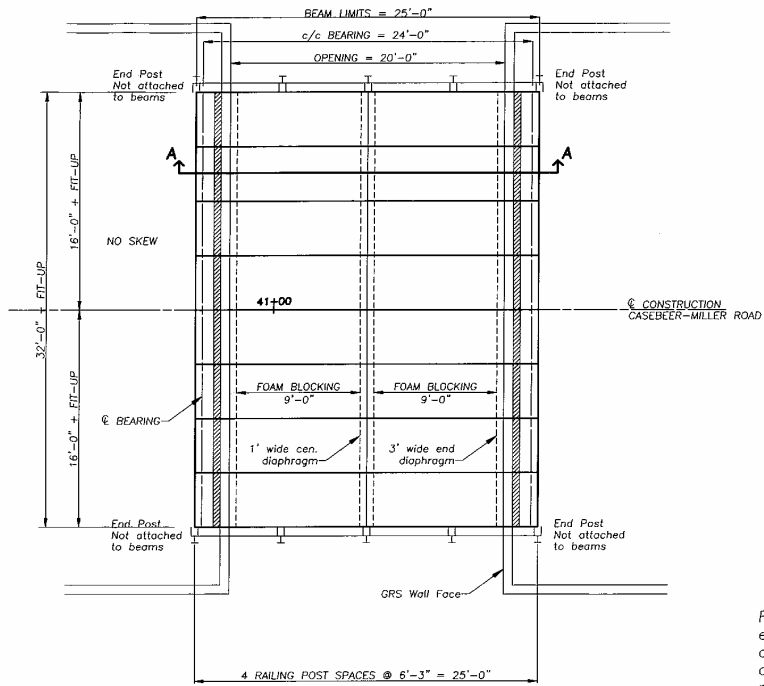
$E = 2,500,000$  psi  
 $E = 2,800,000$  psi (Based on 5,000 psi compressive strength)  
 $E = 2,500,000$  psi

$E = 2,500,000$  psi

# Design Information

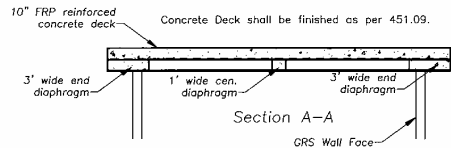
- 20' clear opening 24'span 25' beam length
- 32' width
- Using LFD concept-dead load factor of 2 and live load factor of 5 on HS25 and Alt Mil load
- Truck assumed distributed over 3 beams similar to Prestressed Concrete Box Beams



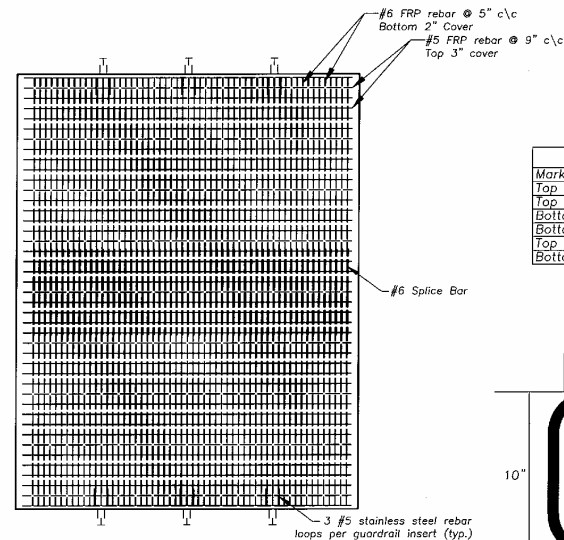


BEAM LAYOUT PLAN

Concrete Quantity 32 CY

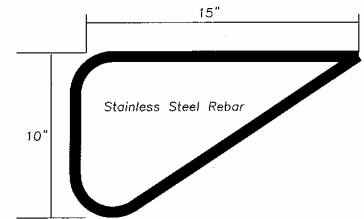


Section A-A

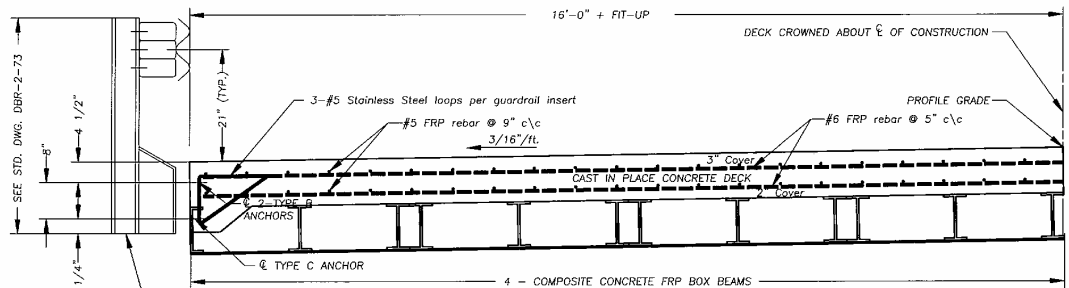


FRP REBAR LAYOUT PLAN

FRP Deck Bar			
Mark	Qty	Size	Length
Top Mat Long	43	5	24'-6"
Top Mat Lat	56	6	15'-9"
Bottom Mat Long	43	5	24'-6"
Bottom Mat Lat	56	6	15'-9"
Top splice	56	6	60"
Bottom Splice	56	6	60"



FRP bars shall be made of glass fiber-reinforced polymer. Bar sizes are in eighths of an inch as in steel rebar. Bars shall have a minimum modulus of elasticity of 5700 ksi. All bars shall have a guaranteed tensile strength of 90 ksi. All FRP bars are straight. All ties and chairs shall be non-ferrous as well.



TYPE 2 POST  
FOR ADDITIONAL RAILING AND BLOCKOUT DETAILS  
SEE STD. DWG. DER-2-73

HALF TRANSVERSE SECTION

# Intriguing Thought

This bridge weigh 800 lb per beam and spans 20'.

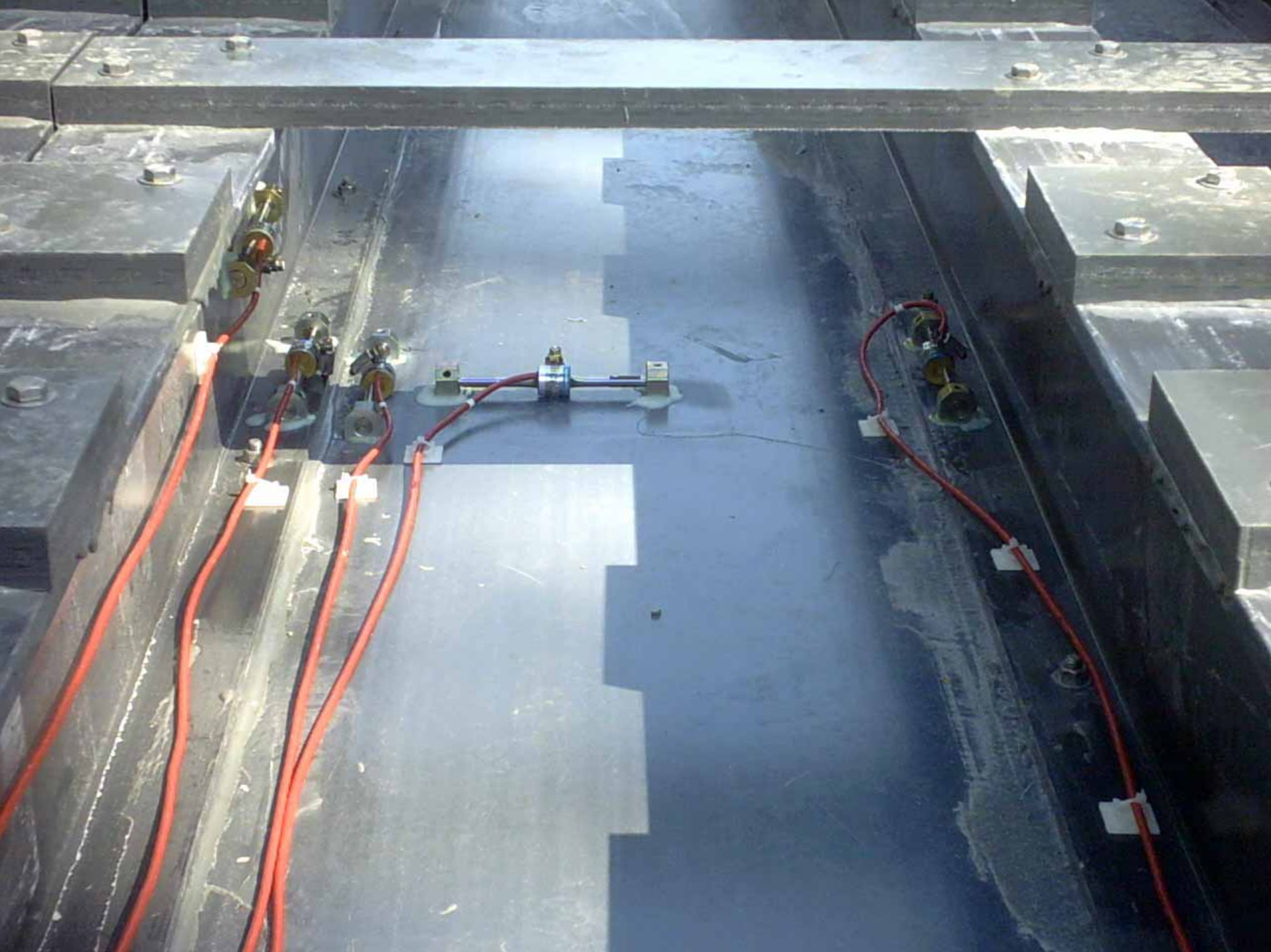
Materials exist to span 50' and each beam would weigh 3100 lb

# Good News

Concept works and works well

















# Load Testing Results

- Bridge stiffness and strains correlate well to theoretical except that the load is being carried almost equally across the eight beams rather than the 3 used in design.
- We plan to monitor temperature and stress over year and then repeat load test.

# Contractor Impression

- Beam manufacturer/fabricator was very interested in pursuing concept.
- Contractor thought project went well and materials were easy to work with
- No significant change orders, just quantity changes at contract unit prices.

# Bad News

\$\$\$\$ Cost \$\$\$\$

# Cost Comparison

- Conventional Capped Pile Abutments \$50,018
- Prestressed Concrete Box Beams w/ paving \$53,296
- Total \$103,314
- Superstructure \$53,296
- GRS Abutments \$36,828
- FRP Beams \$90,694
- Concrete Deck \$7,776
- FRP Rebar \$12,500
- Total \$147,798
- Superstructure \$110,970

# Cost justification

- Total Package would need to last 104 years at a discount rate of 1.8%.
- Superstructure would have to last 104 years at 0%, 170 years at 1%
- In summary, unless the site demands that no heavy equipment be used, FRP cannot be cost justified.