Implementation of Press-Brake-Formed Steel Tub Girders

March 7, 2024

Karl Barth, Ph.D.,
West Virginia University
Dept. of Civil & Env. Engineering

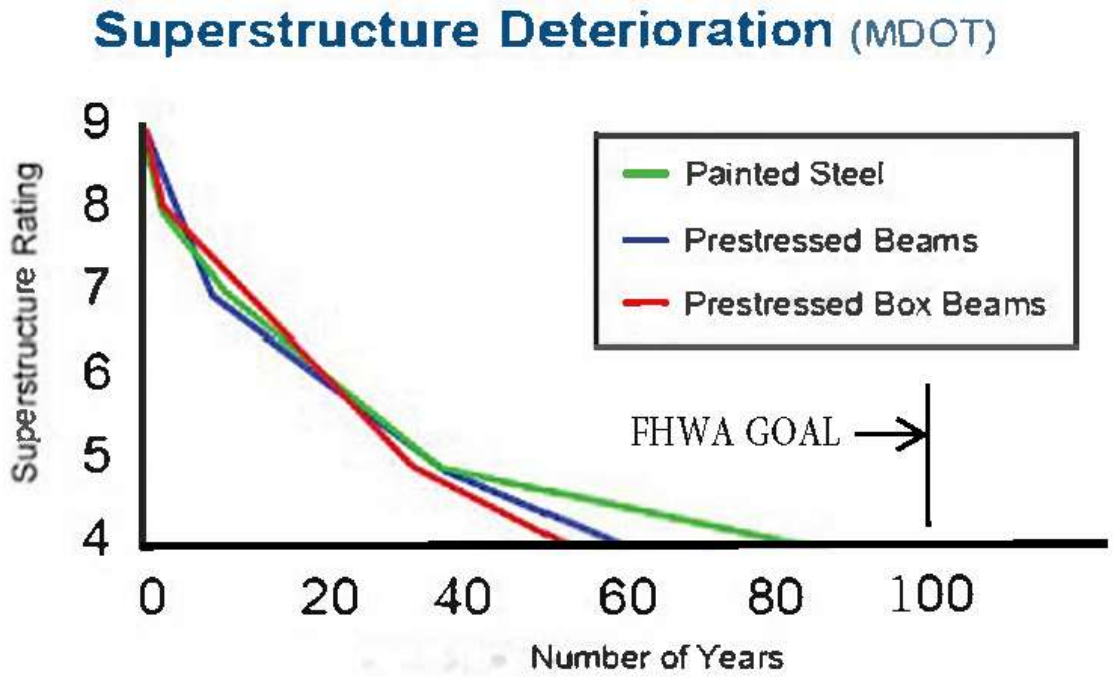
So why do we need a different solution?

"Doing the same thing over and over and expecting different results is insanity"

Albert Einstein

- Prestressed concrete box beams have been the standard solution since the 1970's for off-system, local agency, non-interstate bridges.
- MDOT study of current inventory shows pre-stressed concrete box beam service life < 50 years
- "Bridge engineers need improved design options so they can deliver bridges that are operational for 100 years or more", FHWA

1970 + 50 years = NOW!

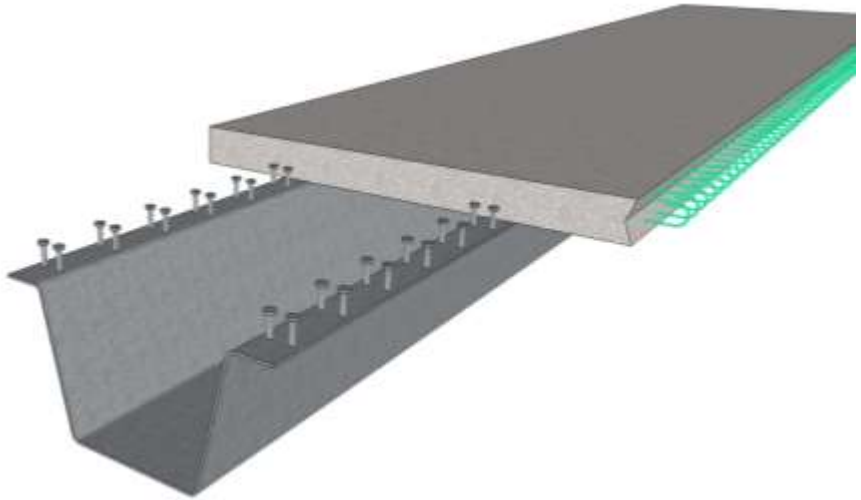


4 - POOR CONDITION - structural capacity of element is affected or jeopardized by advanced deterioration, section loss, spalling, cracking, or other deficiency

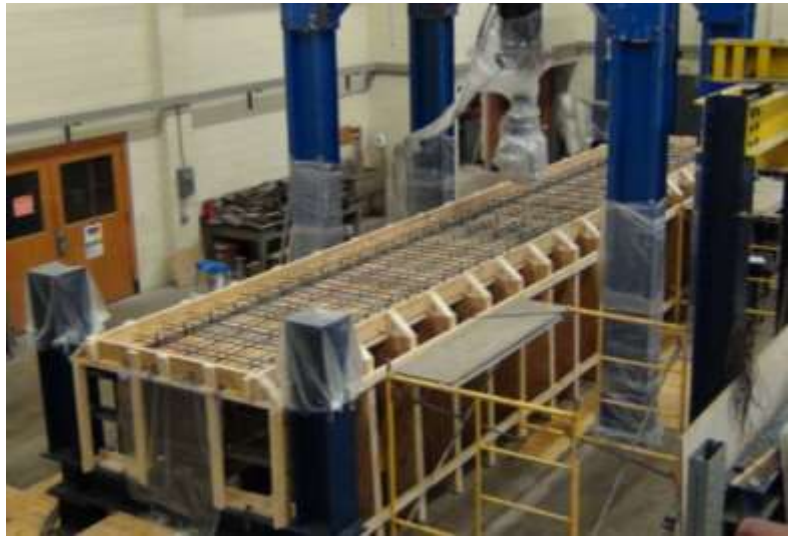
3 - SERIOUS CONDITION - loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible.

Proposed PBFTG System

- Bridge Technology Center:
  - Modules with steel press-brake tub girders
    - Galvanized or Weathering
  - Modules are joined using UHPC longitudinal closure pours
  - Modules can be shipped to site pre-topped with concrete or with a variety of other deck options



Experimental Testing



Experimental Testing (cont'd)

Noncomposite Section Capacity

- Global lateral-torsional buckling will govern for the proposed system:

Experimental = 95.0 kip

Theoretical = 92.3 kip

$$M_{cr} = \frac{\pi^2 E I_y \beta_x}{2L^2}\left[1 \pm \sqrt{1 + \frac{4}{\beta_x^{\,2}}\left(\frac{GJL^2}{\pi^2 E I_y} + \frac{C_w}{I_y}\right)}\right]$$

  - Note the "±" results from the direction of applied moment:
    - Section is stronger if the larger flange is in compression

Modular Unit Specimen Construction

Modular Unit Fatigue Loading (67.43 kip, 0.75 Hz Frequency)

Press-Brake-Formed Tub Girders

External Reusable Formwork

Rebar Layout

Deck Pour

Modular Unit “Dry” Fit

Super and Skew

Aerial Views

Delivery of Modular Units

Modular Unit Placement

Fourteenmile Creek in Ranger, WV

Second Unit Placement

Girders Set and Formed

UHPC Pour

2021 AASHTO Focus Technology

NATIONAL RECOGNITION WITH THE AASHTO INNOVATION INITIATIVE AWARD

2020	Press-Brake Tub Girders receive the “2020 Innovation Award” as **a ready-to-implement technology** that offers improved performance/effectiveness, and have been demonstrated in "real world" applications.
2021	Press-Brake Tub Girders become a 2021 AASHTO Focus Technology
2023	Press-Brake Tub Girders to be included in revisions to the 10th Edition of the AASHTO LRFD Bridge Design Specifications. The revisions apply to Specification Equation 6.11.2.2-3, allowing DOTs, Counties and other entities to utilize AASHTO design guidelines instead of rewriting specifications to include U-BEAMs

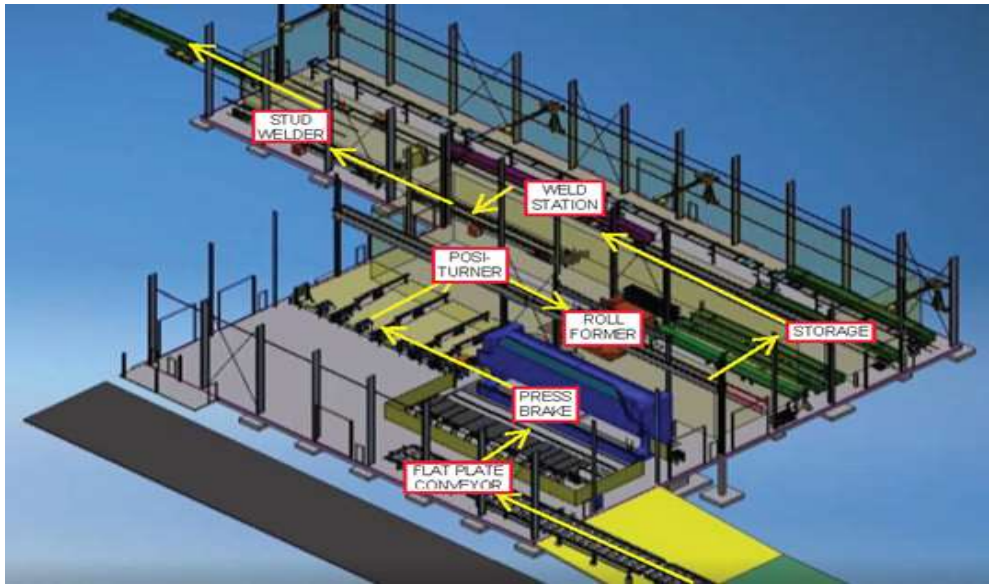
“This is great news for state and local Departments of Transportation that are looking for economical, sustainable and accelerated construction solutions for short span bridges, which make up over half of the U.S. bridge inventory.”

- Karl Barth, Ph.D., Associate Professor of Civil and Environmental Engineering at West Virginia University in a recent SSSBA article about the revisions

Valmont Manufacturing Innovation

STATE OF THE ART PRESS BRAKE FABRICATION FACILITY:

- AISC intermediate bridge fabricator certification
- Patent pending manufacturing techniques
- increased production capacity by 5
- Total Capitol investment $20M
- Cut production time by 70%
- U-beam^{tm} facility fully staffed with new personnel
- Designed for manufacturing efficiency and reduced carbon emissions



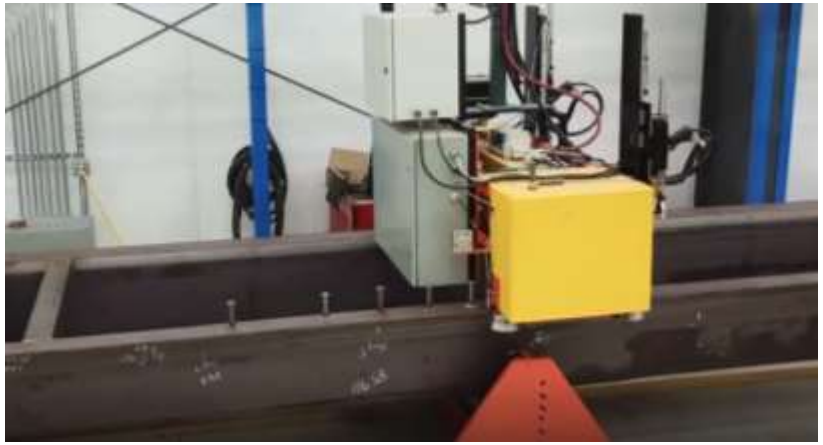
Valmont Manufacturing Innovation

STATE OF THE ART PRESS BRAKE FABRICATION FACILITY:

- ✓ Open to production August 2021
- ✓ 2000 Ton 60’ Press Brake
- ✓ Roll form camber capabilities
- ✓ Automated stud welding capabilities
- ✓ Safe and efficient material handling
- ✓ AISC IBR bridge fabrication certification

ROLL CAMBER PROCESS

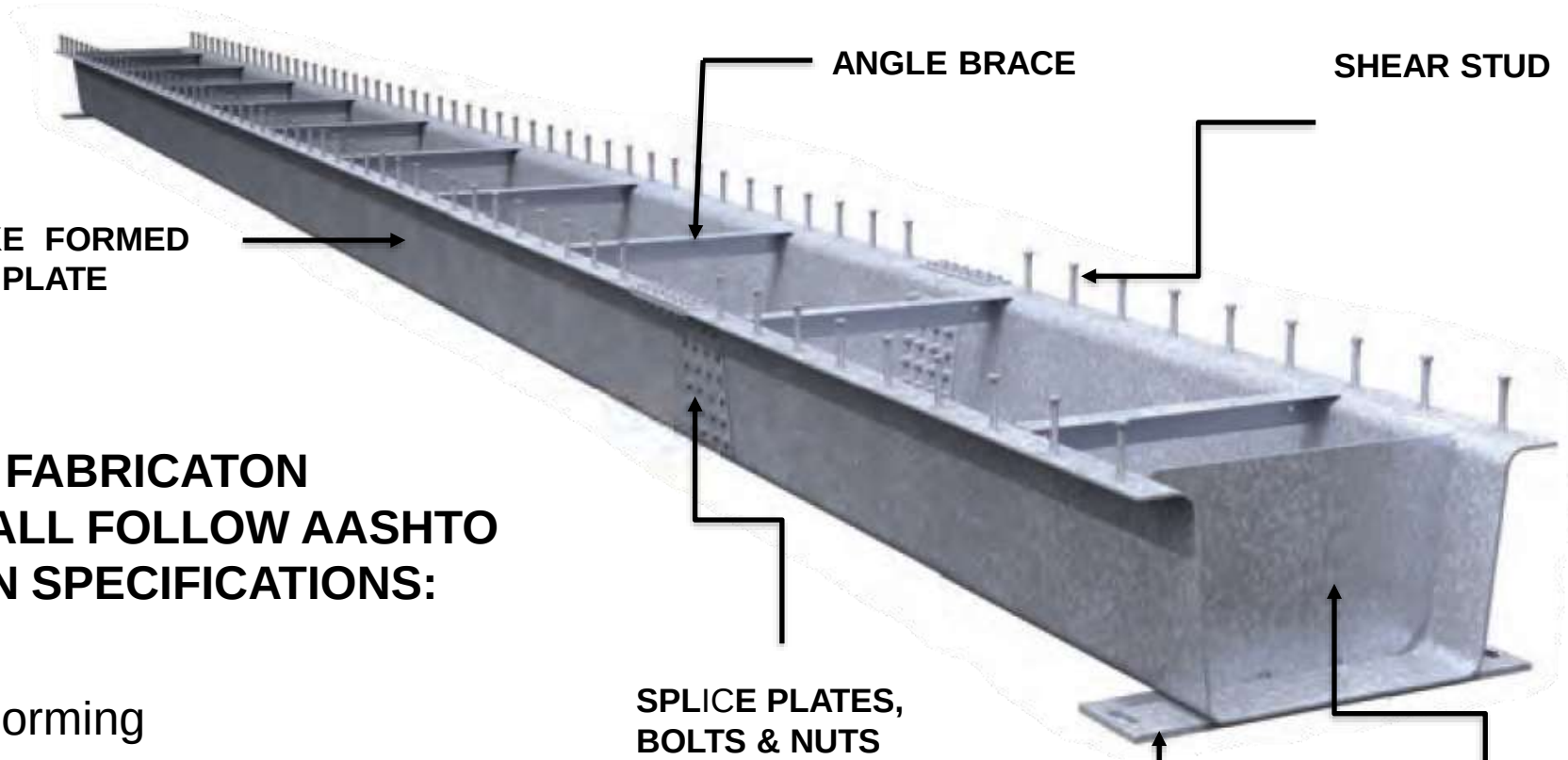
60’ PRESS BRAKE



AUTOMATED STUD WELDING

FINISH WELD STATION

The Valmont U-BEAM™ (a press brake formed steel tub girder)



ONLY 5 SIMPLE FABRICATON PROCEDURES ALL FOLLOW AASHTO CONSTRUCTION SPECIFICATIONS:

1. Material
2. Press-Brake Forming
3. Camber
4. Welding
5. Protective Coating

#1 AASHTO STEEL PLATE MATERIAL

AASHTO 11.3.1.2
AASHTO M270. **Made in the USA**. Steel Plates and Structural Shapes shall conform to ASTM A709/A709M.

#2 AASHTO FORMING

AASHTO 11.4.3.3 - Bent Plates
Fracture-critical and Non-fracture critical plates and bars shall be cold bent.

#3 AASHTO CAMBERING

AASHTO 11.4.12.2.7

Cold cambering is a customary means of achieving camber…to avoid impact damage to the steel, is appropriate to introduce bending pressure in a controlled fashion.

#4 AASHTO WELDING AND SHEAR STUDS

AASHTO 11.3.3

Certified Welders and welded stud shear connectors shall satisfy all requirements of the AASHTO/AWS D1.5M/D1.5 Bridge Welding Code related to material, manufacturing, physical properties, certification, and welding.

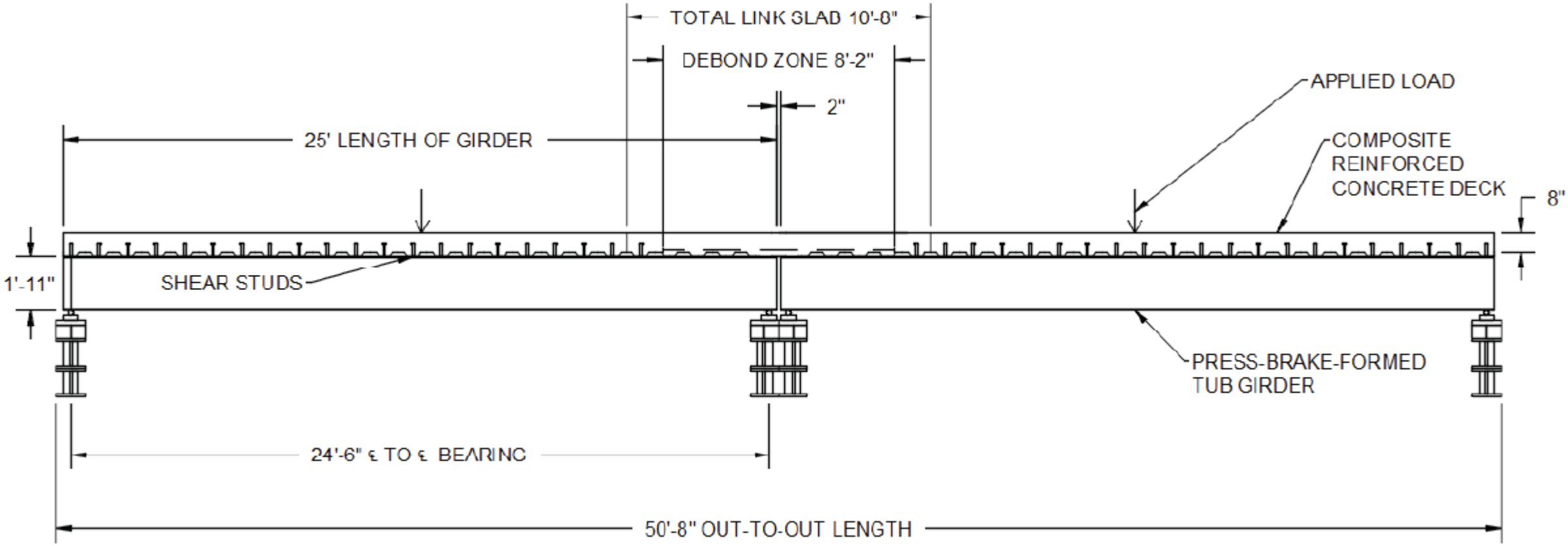
#5 AASHTO PROTECTIVE COATING

AASHTO 11.3.7

Galvanizing shall be in accordance with AASHTO M 111M/M 111 (ASTM A123/A123M)

Continuous Span applications: link slabs

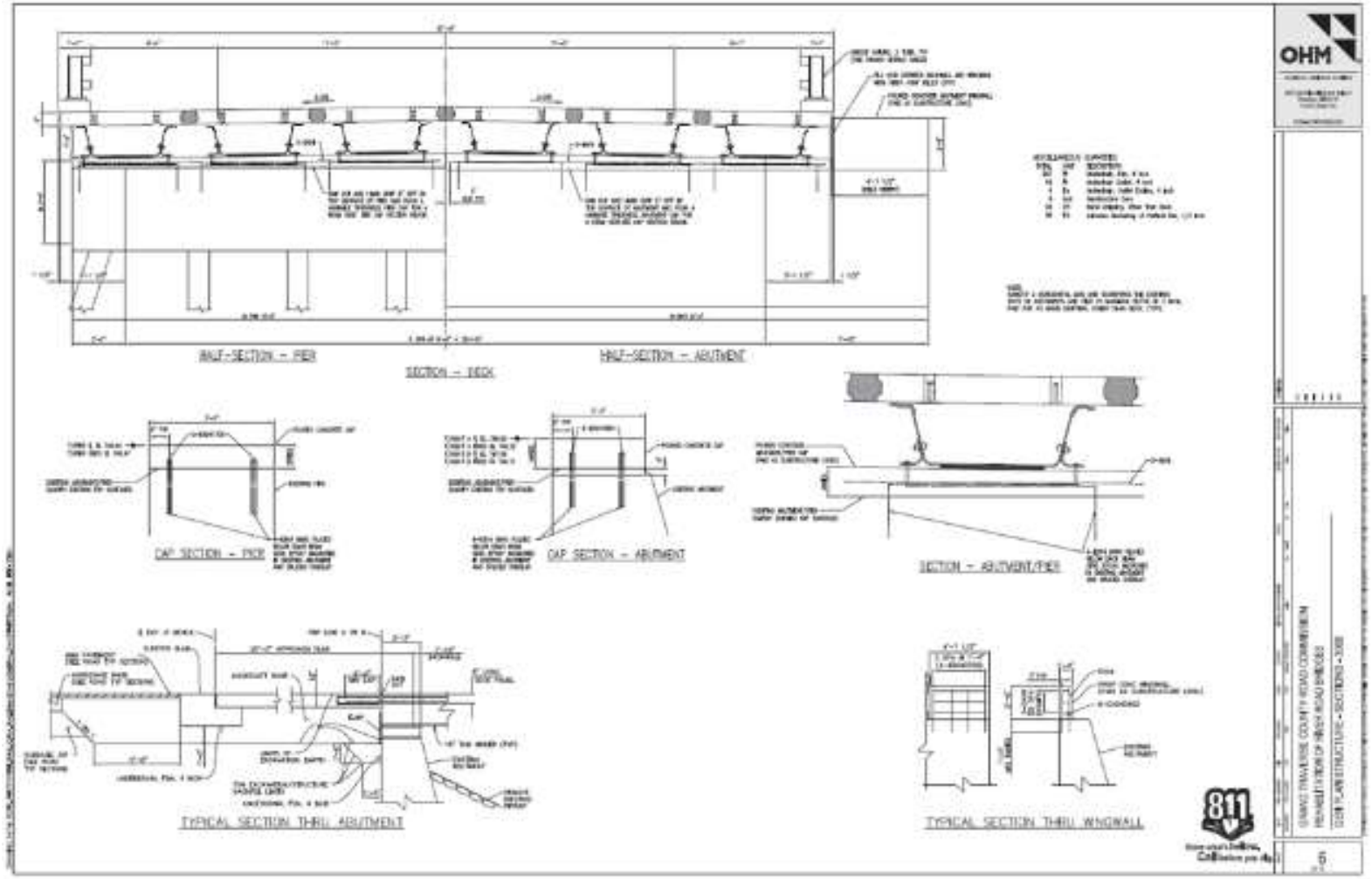
- Full scale link slab between two modular steel tub girders



2021 MDOT GRAND TRAVERSE COUNTY

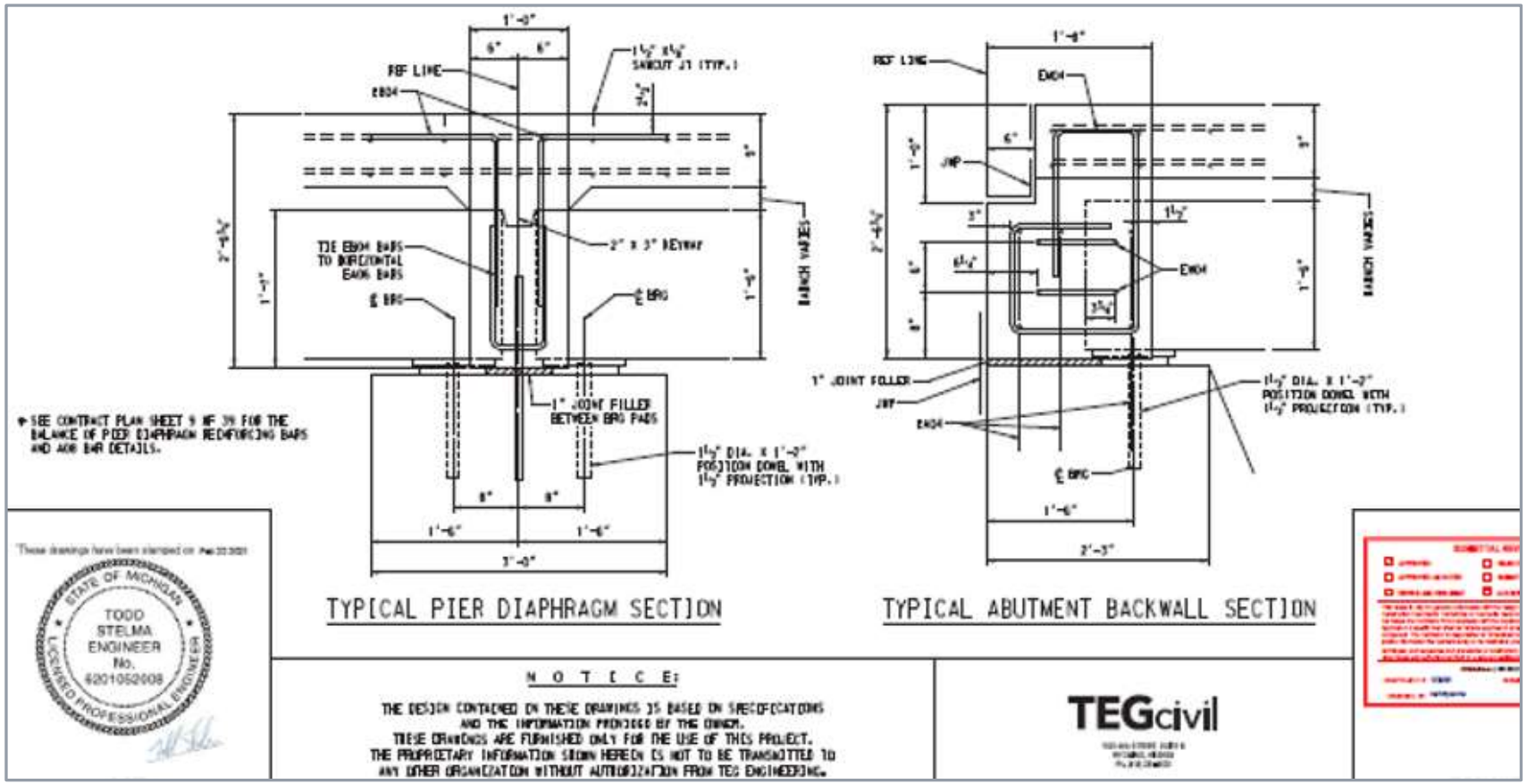
Latest Installation, Grand Traverse County, MI

- Consultant designed as precast concrete bridge deck



Latest Installation, Grand Traverse County, MI

- Contractor chose to VECP cast-in-place deck option



Grand Traverse County, MI Installation

Consultant designed as precast concrete bridge deck, contractor chose to VECP cast-in-place deck option

The Boardman River is considered one of the top ten trout streams in Michigan

Grand Traverse County, MI Installation

2 Span cast-in-place deck, open to traffic 2 week after U-BEAMs delivered

Grand Traverse County, MI Finished Product

Finished Product, August 2021

2 Span Bridge Beams

Continuous Bridge Deck