# Research and Development Efforts Aimed at the Commercial Production of a Shallow Press-Brake Formed Steel Tub Girder

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FIU NABC Workshop W-04

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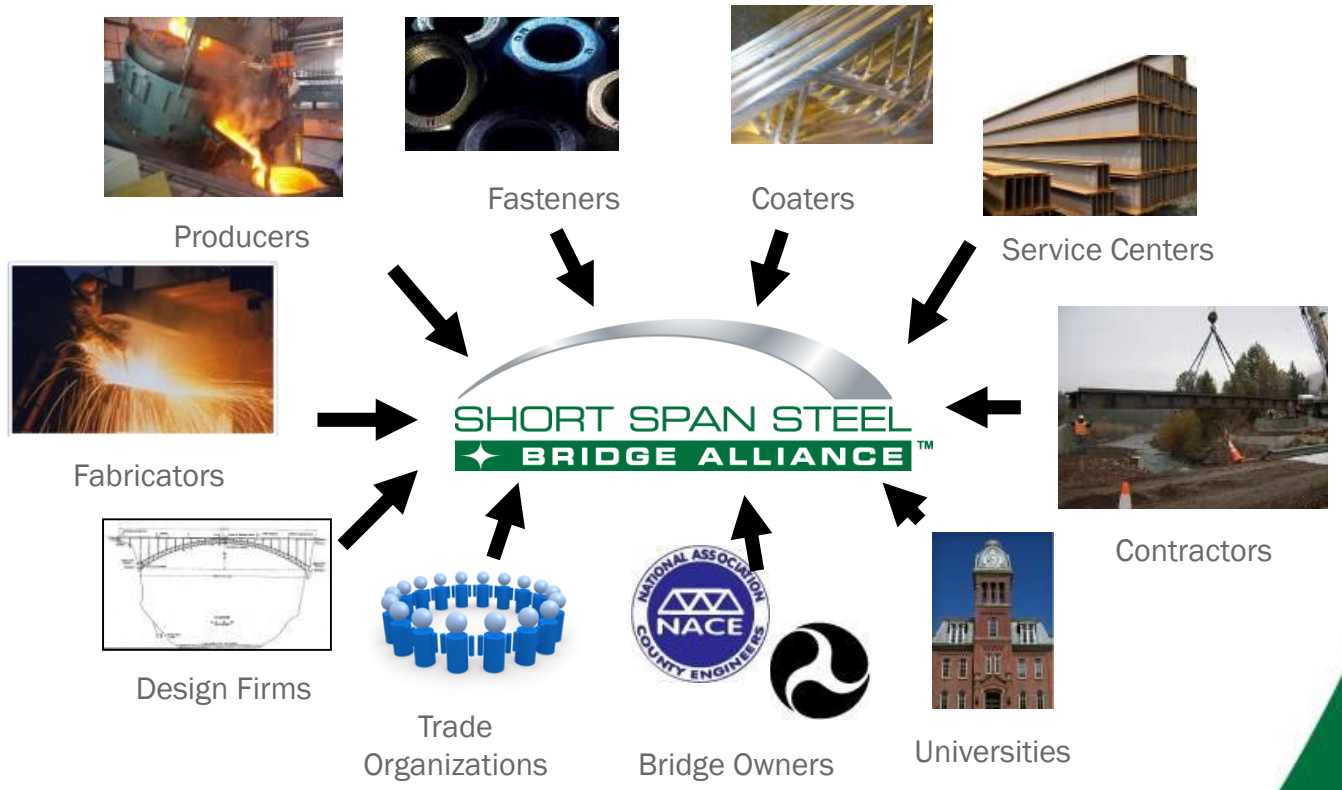
www.shortspansteelbridges.org

# Outline

- Background
  - SSSBA
  - PBFTG Concept
- Proposed System Details & Design Methodology
- Experimental Testing
  - Single Composite Girders
  - Modular Composite Units
- Implementations

# Short Span Steel Bridge Alliance

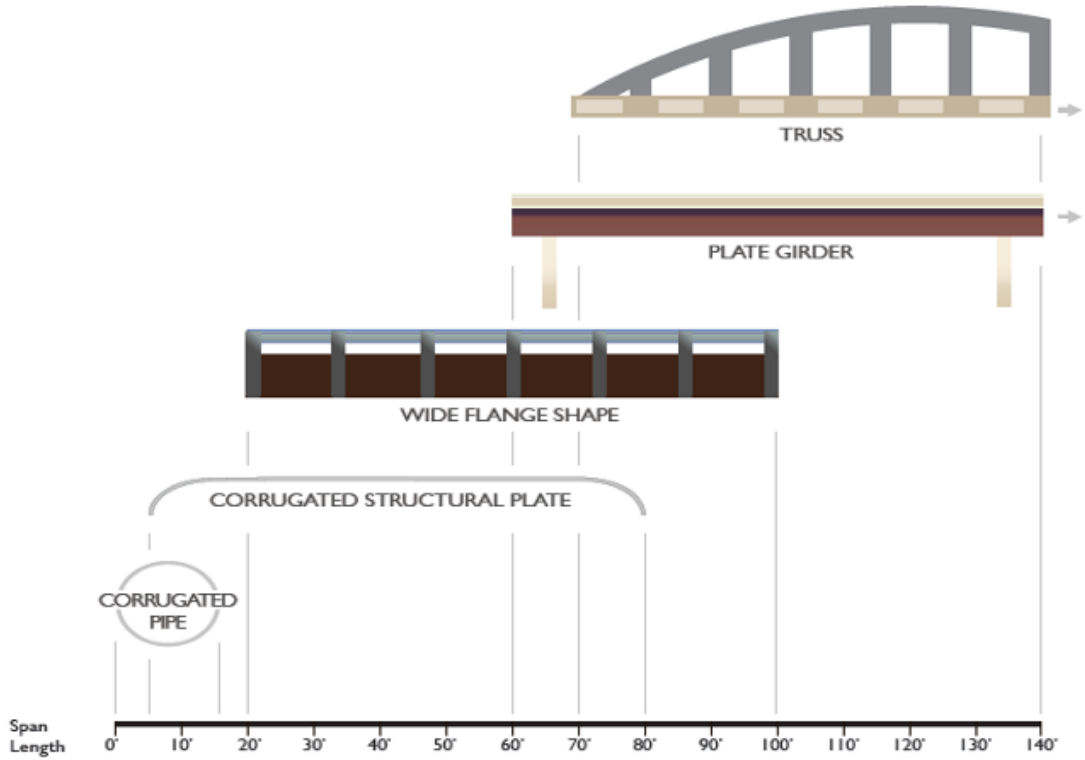
- Program officially started September 2007
  - Objective – make steel the material of choice for short span steel bridges.
  - Short span steel bridges have spans up to 140 ft



# Short Span Steel Bridge Alliance

- What does SSSBA do:
  - Education (webinars, workshops, forums, conferences)
  - Technical Resources (standards, guidelines, best practices)
  - Case Studies (economics: steel is cost-effe
  - Simple Design Tools (eSPAN140)
  - Answer Questions (Bridge Technology Cent
  - Access to Industry Partners (industry conta list)
  - **All FREE for bridge owners, designers, & universities**

Our focus is to provide solutions for spans up to 140 ft. in length!



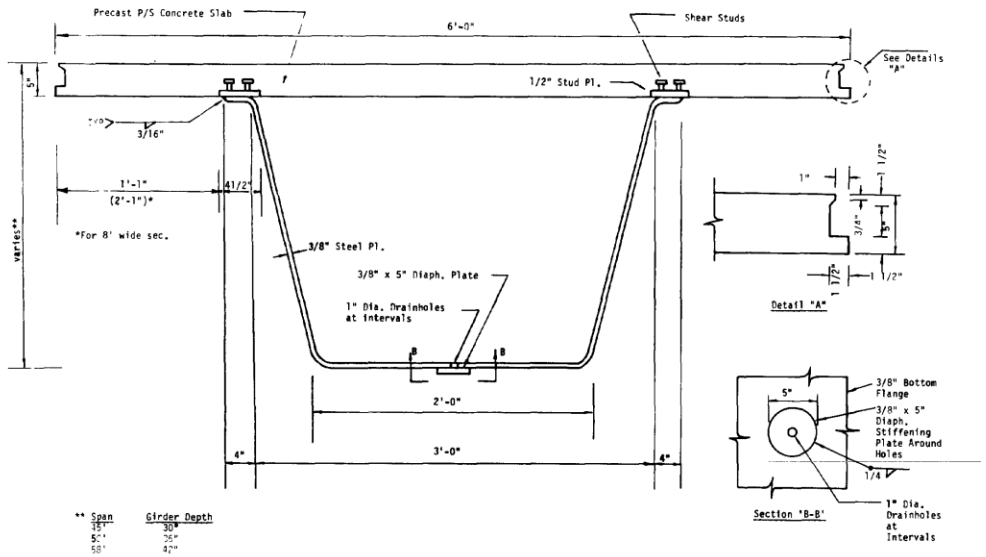
# FIU NABC Conference

- Stop by **Booth 203** for more information:

- Also, check out some of our SSSBA Members
  - 211 Acrow Corporation of America
  - 510 AZZ
  - 210 National Steel Bridge Alliance
  - 513 U.S. Bridge
  - 105 Valmont/TEG Engineering

# Background

- Concept has been in place since 1970s
  - “Prefabricated Press-Formed Steel T-Box Girder Bridge System”
    - AISC Engineering Journal
    - Taly & GangaRao, 1979
    - (Significant input into the original concept development was given by Dr. Larry Luttrell, a key authority on cold bending of steel.)



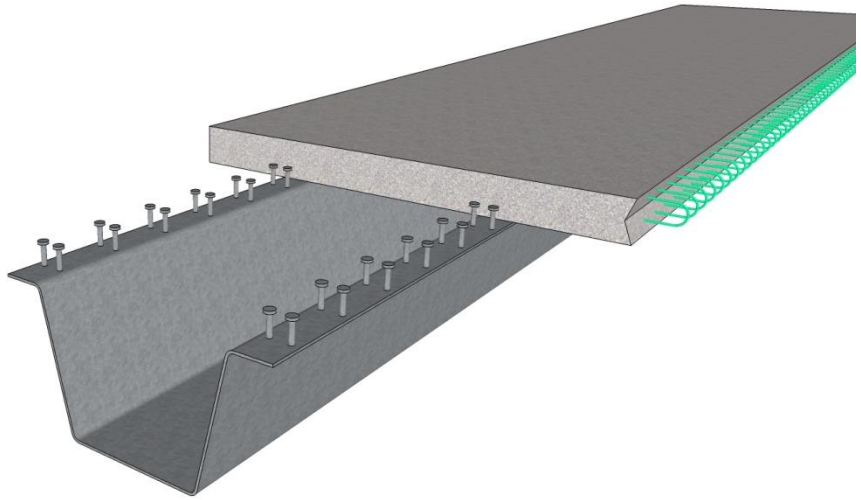
# Background (cont'd)

- Why didn't this take off?
  - Concrete deck option would require refinement of expensive fabrication details
  - Lack of proof of concept testing
  - Lack of industry support

- Similar systems have been proposed that include:
  - Prestressing components
  - Inefficient girder cross-sections
  - Complex fabrication details

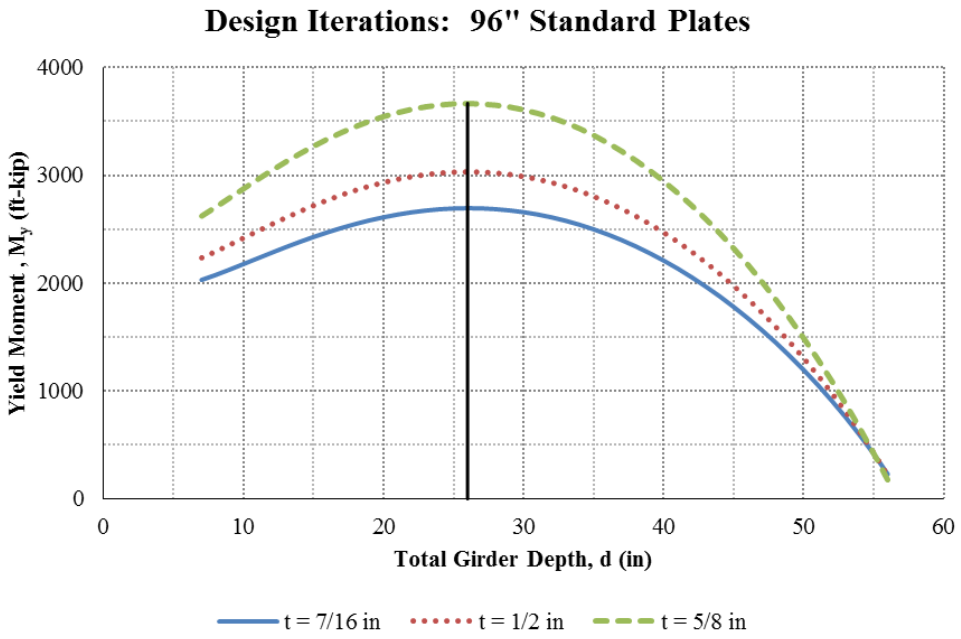
# Proposed System

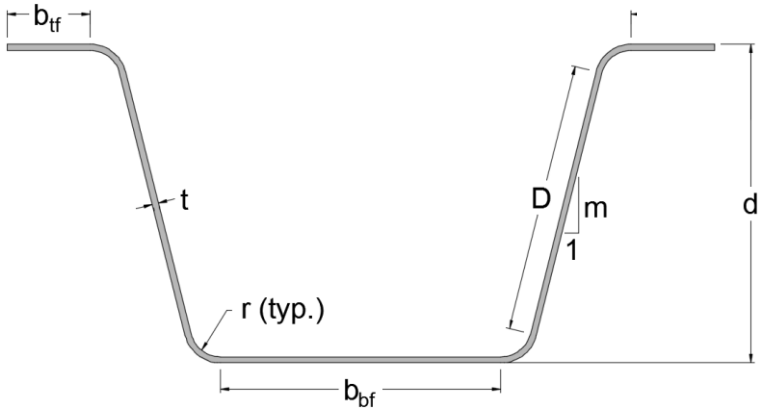
- Bridge Technology Center:
  - Modules with steel press-brake tub girders
  - Modules are joined using UHPC longitudinal closure pours
  - Modules can be shipped to site pre-topped or with a variety of deck options



# Design Methodology

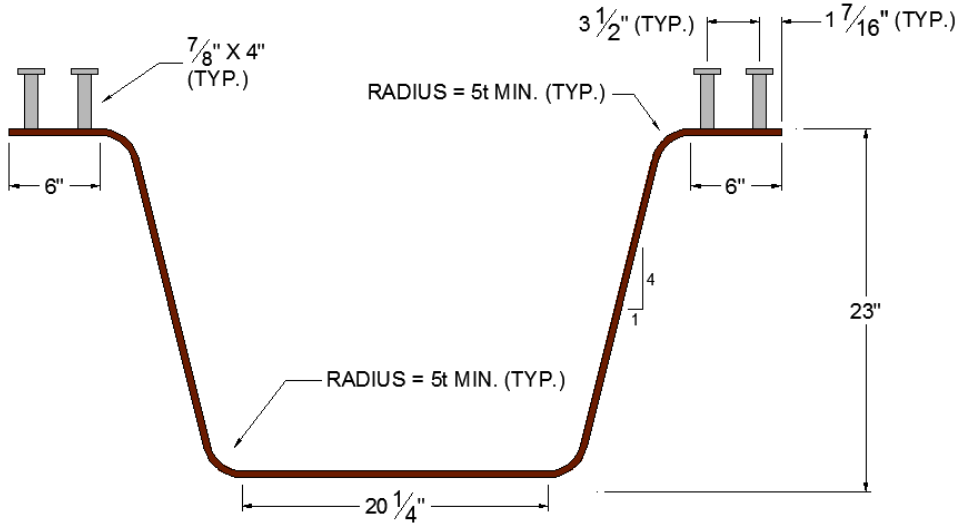
- Goal:
  - Utilize standard plate widths
    - 84”, 96”, etc.
  - Maintain 1:4 web slope, “5t” radii, and 6” btf
    - Consistent w/ AASHTO Spec.
  - Optimize girder dimensions to attain maximum capacity



# Design Methodology (cont'd)

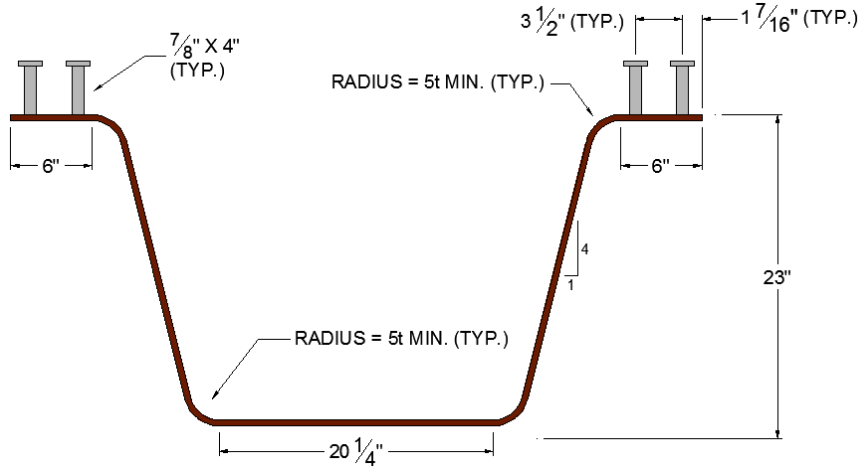
- Resulting girder depths:
  - 60" plate: d = 12"
  - 72" plate: d = 17"
  - 84" plate: d = 23"
  - 96" plate: d = 26"
  - 108" plate: d = 30"
  - 120" plate: d = 34"

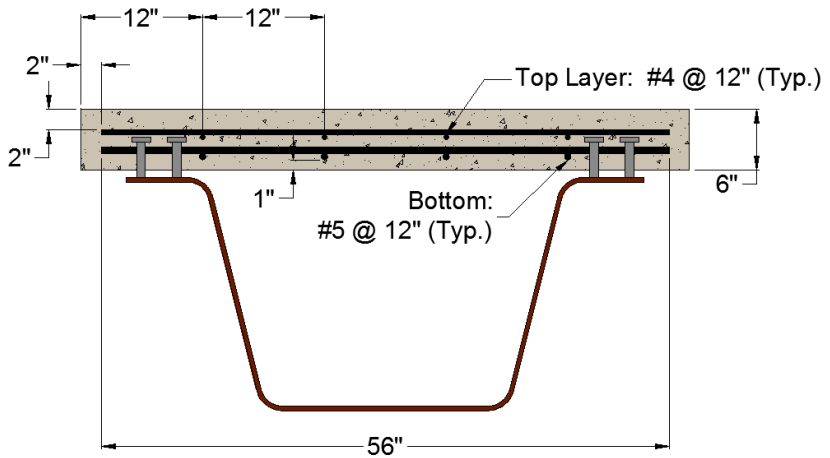



- All composite section properties are available upon request.

# Experimental Testing

- Testing was conducted on composite, noncomposite, and modular flexural specimens:
  - 84” × 7/16” PL
  - Dimensions shown below:



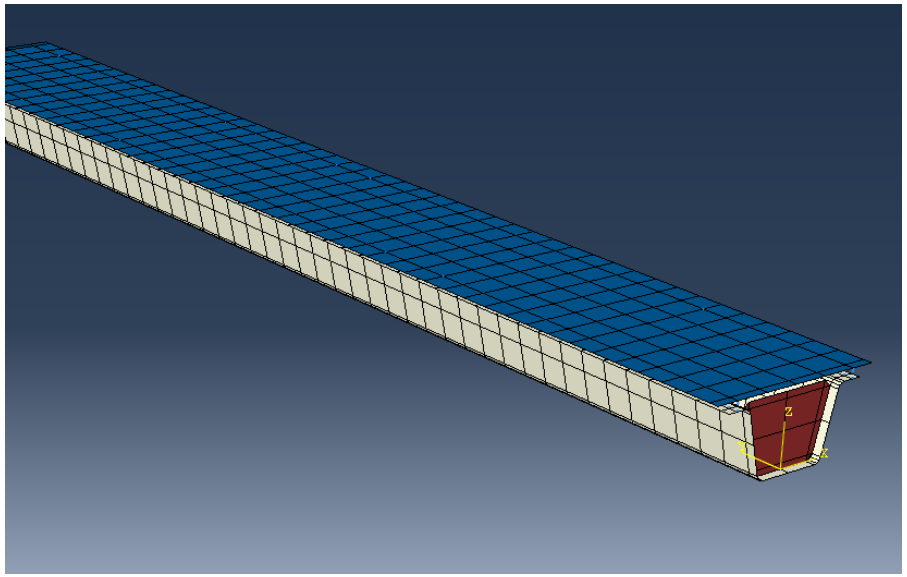
# Experimental Testing (cont'd)

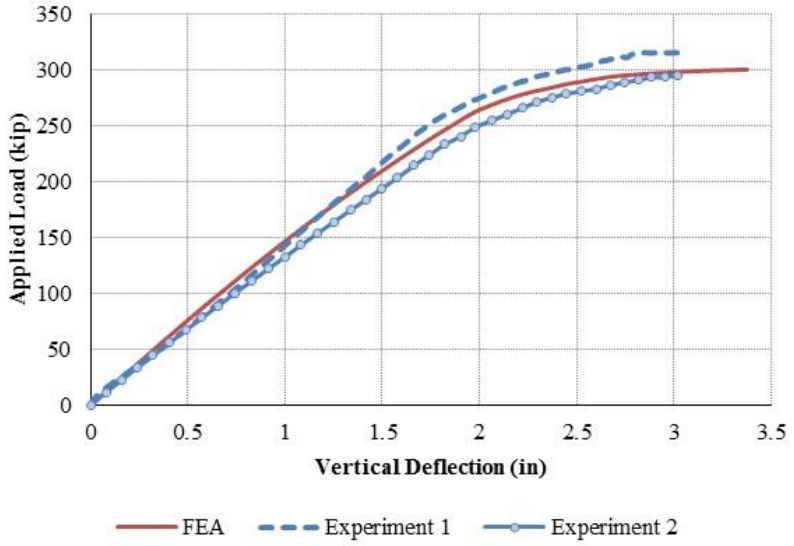
# Experimental Testing (cont'd)

# Experimental Testing (cont'd)

# Analytical Methods

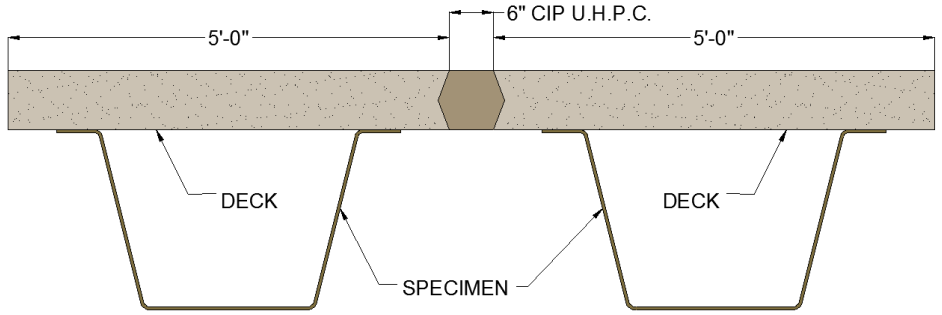
- FEA was completed using Abaqus/CAE
  - S4R shell elements were employed to simulate the girder and deck
  - von Mises material laws governed steel behavior
  - A smeared cracking model incorporating tension stiffening was employed for concrete behavior





# Modular (UHPC) Fatigue Lab Test

- To date, tests on singular tub-girder units (both in their composite and noncomposite states) have been completed.
  - Recent testing efforts have been focused on assessing the concept's system-level behavior.




- Modular test goals:
  - Assessing best practices for closure pours.
  - Assess the performance of:
    - UHPC Closure Pours
    - Press-brake-formed tub girders under fatigue loading.

# Modular Unit Specimen Construction



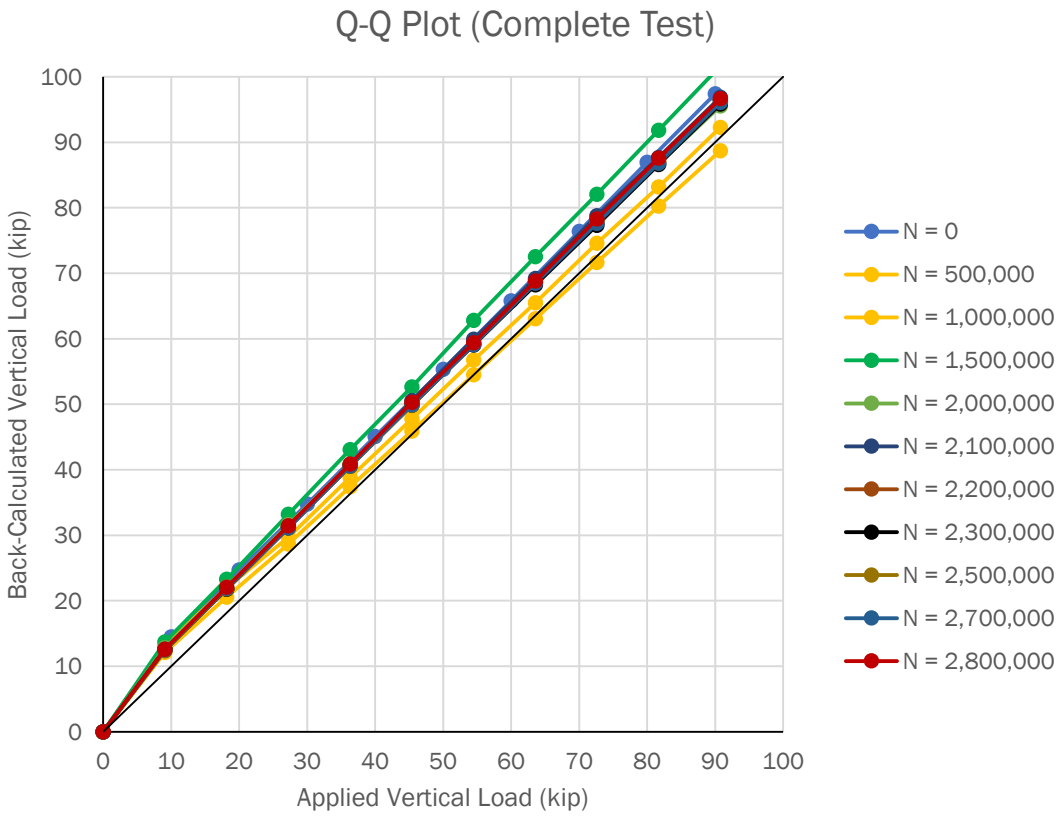


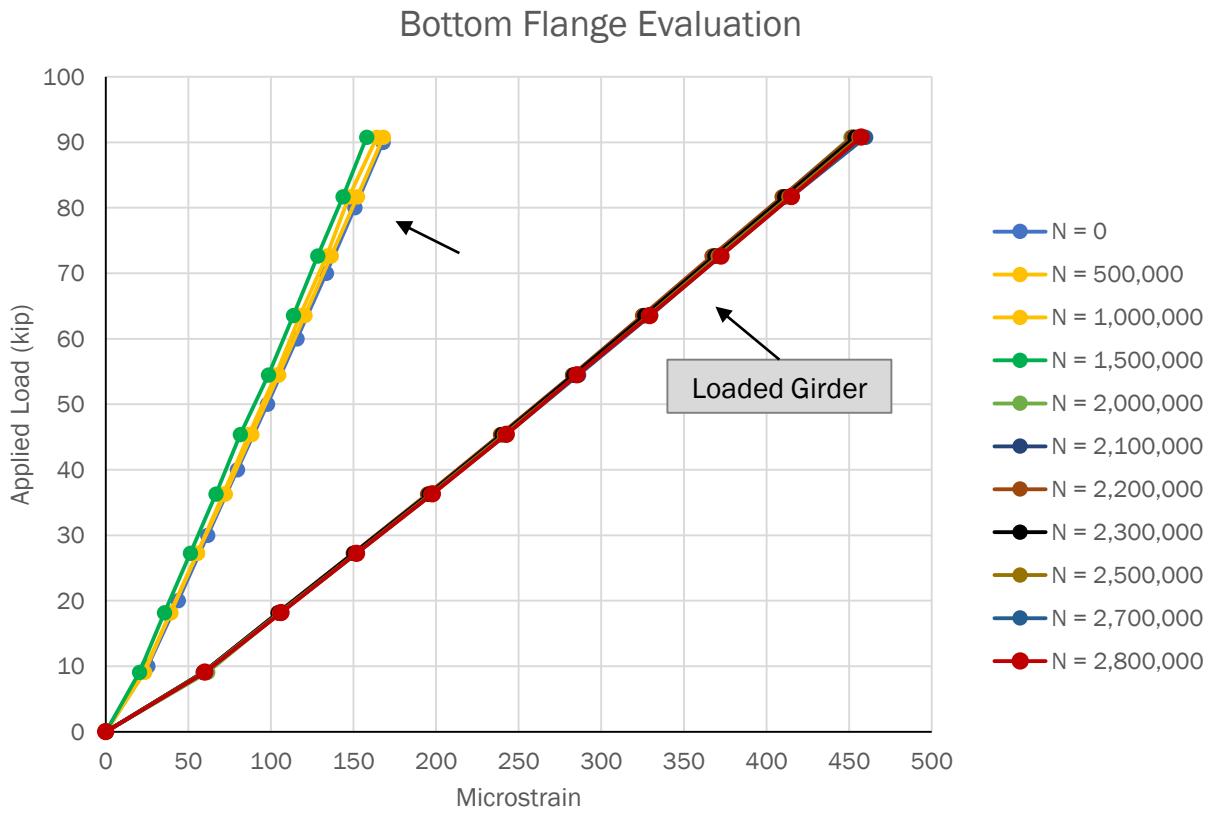

# Modular Unit Specimen Construction (cont'd)

# Modular Unit Fatigue Loading (67.43 kip, 0.75 Hz Freq.)

# Exp. Test Results (Modular Unit, Service II Loading)

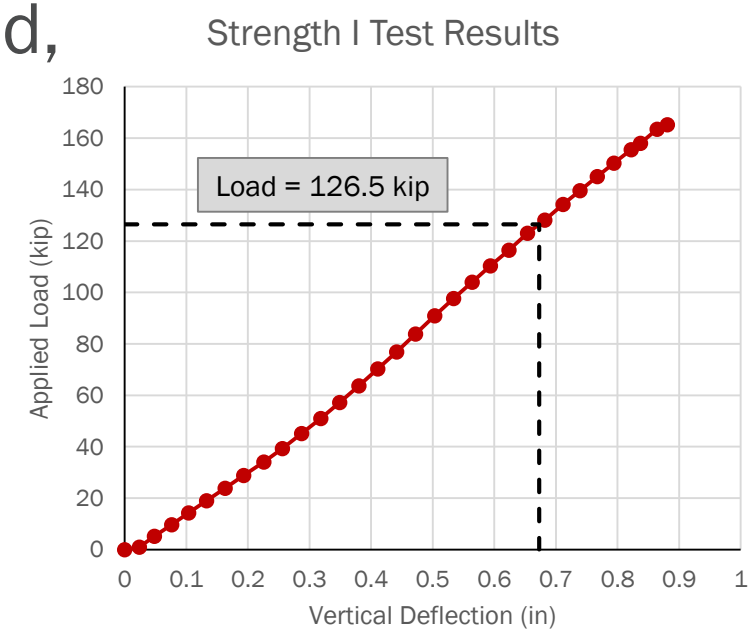
- Service II Live Loading (max bottom flange stress ≈ 13 ksi):



# Experimental Test Results (Strength Loading)

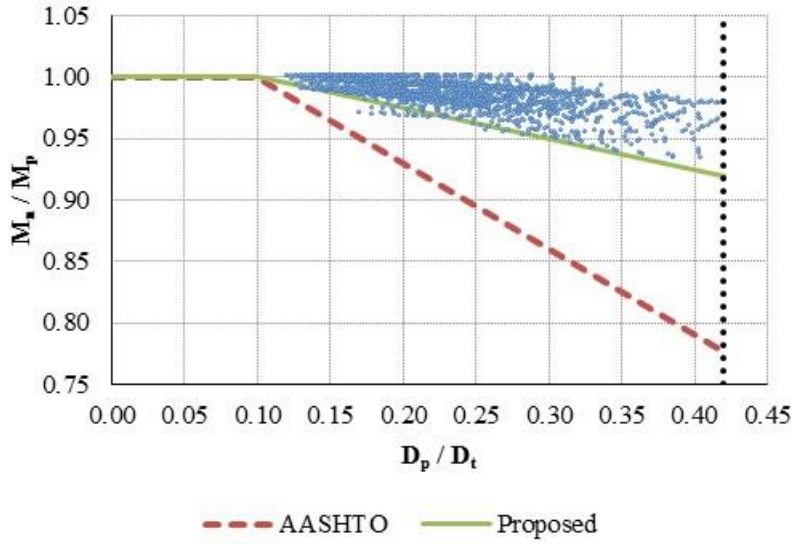
- Once fatigue loading was completed, the specimen was loaded to (and well past) the strength limit state.
  - For safety concerns, specimen was loaded in stroke control.
  - As shown, the specimen performed sufficiently and linearly through the Strength I limit state,




- Results:
  - This series of experiments indicate that modular press-brake-formed tub girders will perform adequately through their intended service life!

# Composite Section Capacity

- In order to evaluate the applicability of AASHTO Specifications, a parametric matrix of composite girders was developed (resulting in 900 girders):
  - 18 girders (previously described)
  - 50-ksi and 70-ksi steel employed
  - 25 deck options
    - 5 deck thicknesses (7” to 11” in 1” increments)
    - 5 deck widths (defined based on out-to-out width of the girder

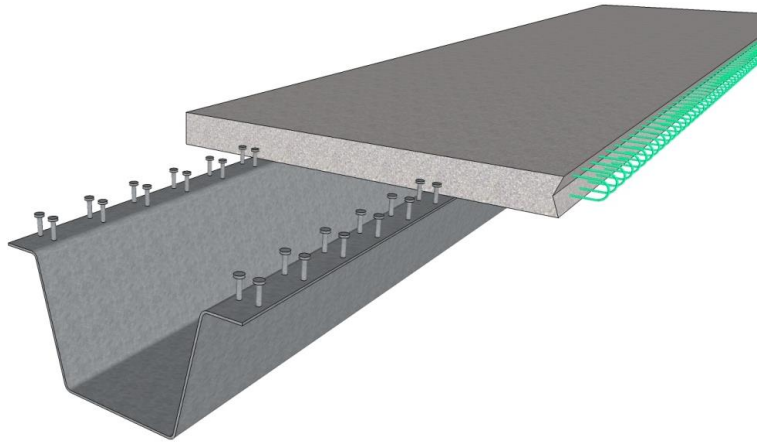


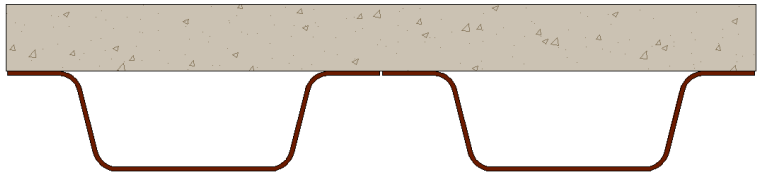

$$M_{n\,(\text{AASHTO})} = \begin{cases} M_p & D_p \le 0.1D_t \\ M_p\left(1.07 - 0.7\dfrac{D_p}{D_t}\right) & 0.1D_t < D_p \le 0.42D_t \end{cases}$$

$$M_{n\,(\text{Proposed})} = \begin{cases} M_p & D_p \le 0.1D_t \\ M_p\left(1.025 - 0.25\dfrac{D_p}{D_t}\right) & 0.1D_t < D_p \le 0.42D_t \end{cases}$$

# Standardization

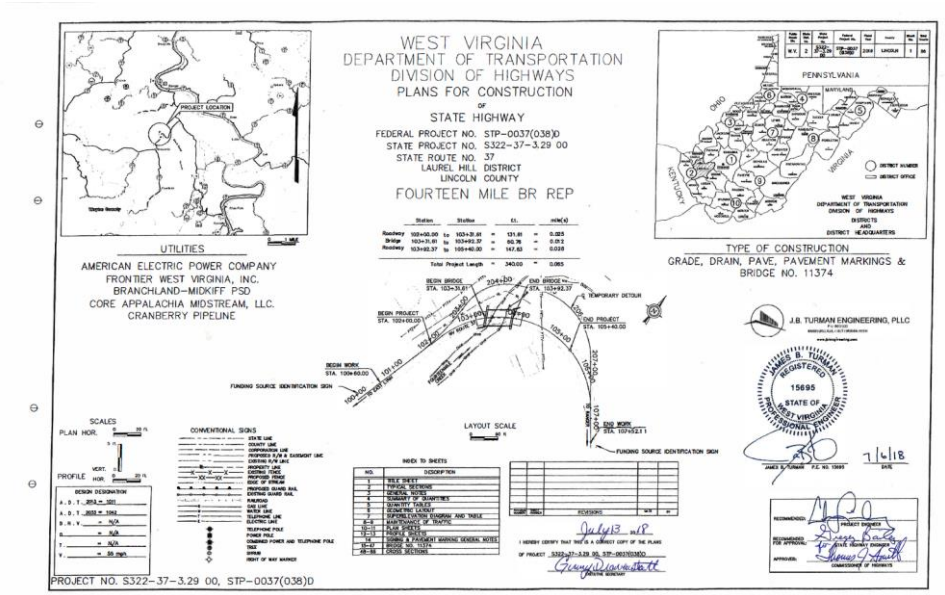
- Based on plate availability and the feasibility of the modular system, the following standardized girders are proposed:
  - PL 72” × 1/2”
    - Applicable for spans up to 40 feet
  - PL 96” × 1/2”
    - Applicable for spans up to 60 feet
  - PL 120” × 5/8”
    - Applicable for spans up to 80 feet
  - Double PL 60” × 1/2”
    - Applicable for spans up to 65 feet

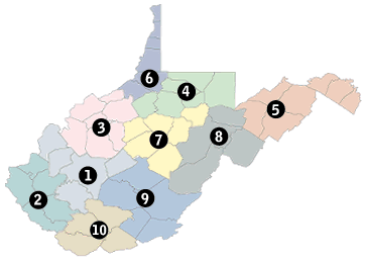


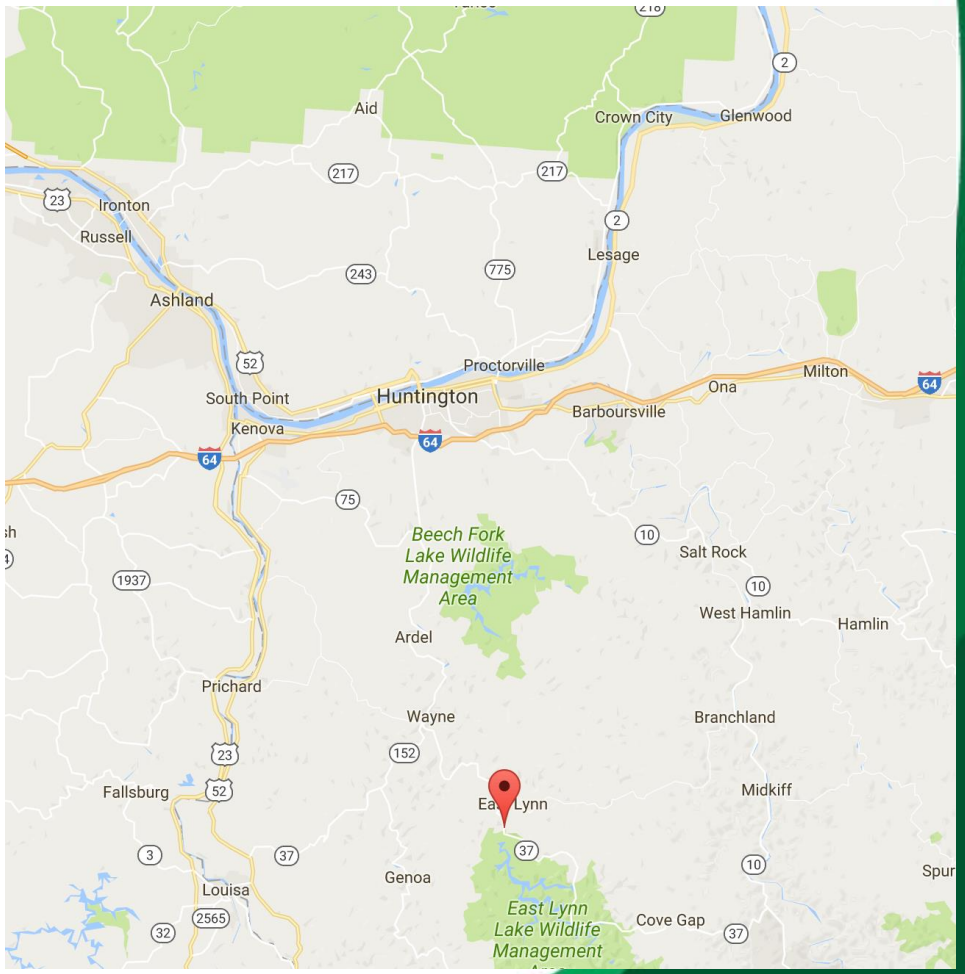


# WV District 2 Project

- Project Overview:
  - Project Kickoff in Q2, 2019
  - Completion in November 2019

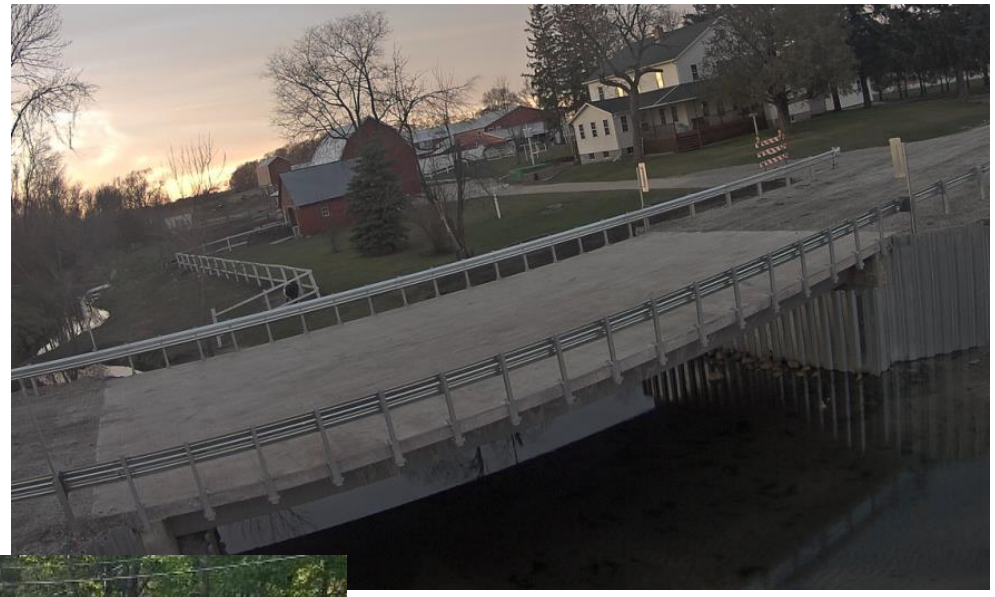




# Additional Projects

- Amish Sawmill Bridge (2015)
  - Buchanan County, IA
- Cannelville Road Bridge (2017)
  - Muskingum County, OH
  - 2018 NSBA Tech. Advancement Award



# Thank You / For More Information

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Questions?