Online Design Tools: *eSPAN140 Demonstration & Design Example*

Steel Bridge Economy & Case Studies

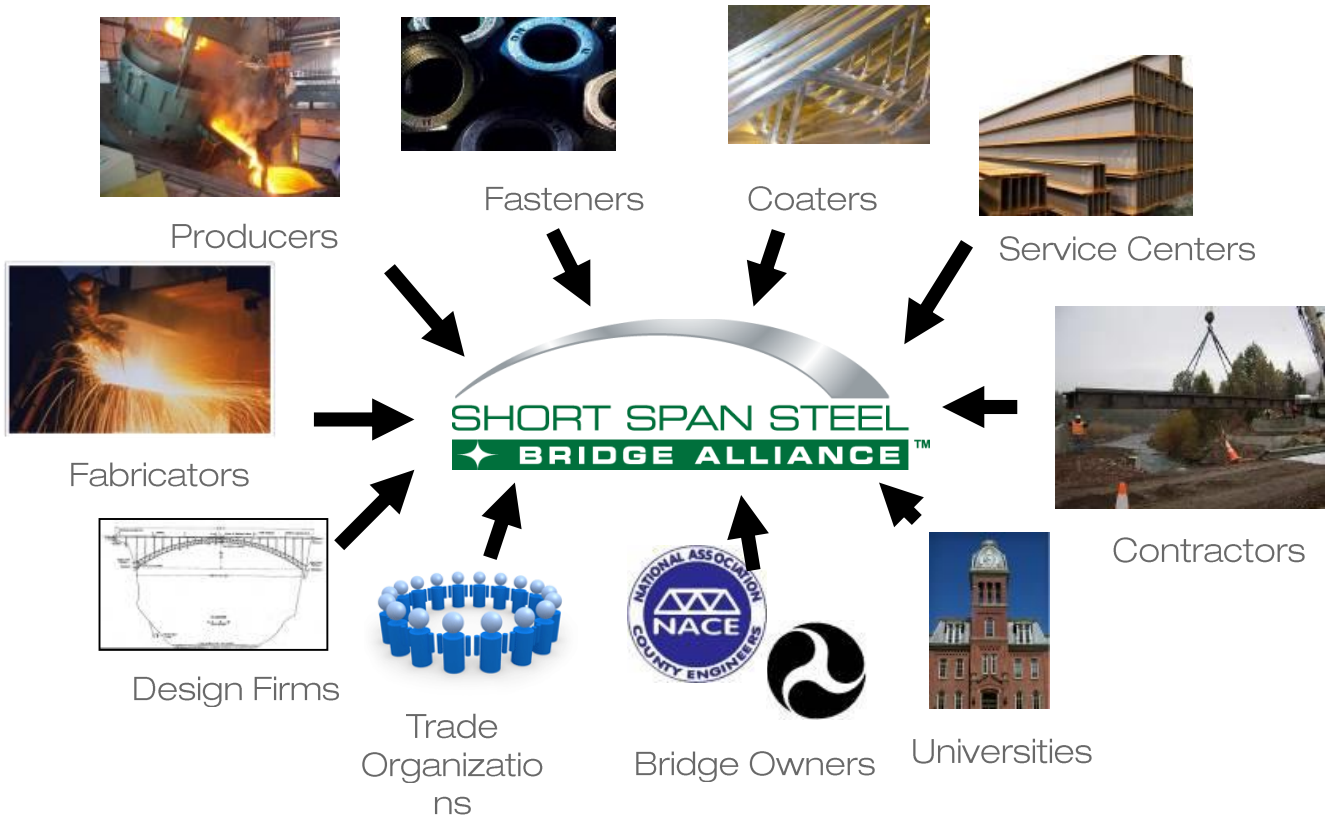
Michigan Bridge Conference: Tuesday, March 20 (Ann Arbor, MI)

Michigan's Local Technical Assistance Program

Gregory K. Michaelson, Ph.D.
Marshall University
michaelson@marshall.edu

The 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
  - First North American industry-wide effort to provide education and design support for short span steel bridges.



SSSBA Website

- eSPAN140 Web-based Design Tool
- Bridge Technology Center
- Technical Design Resources
- Project Case Studies
- News Updates & Social Media (Twitter / LinkedIn / Facebook)
- Email Newsletter (sign-up to receive it)

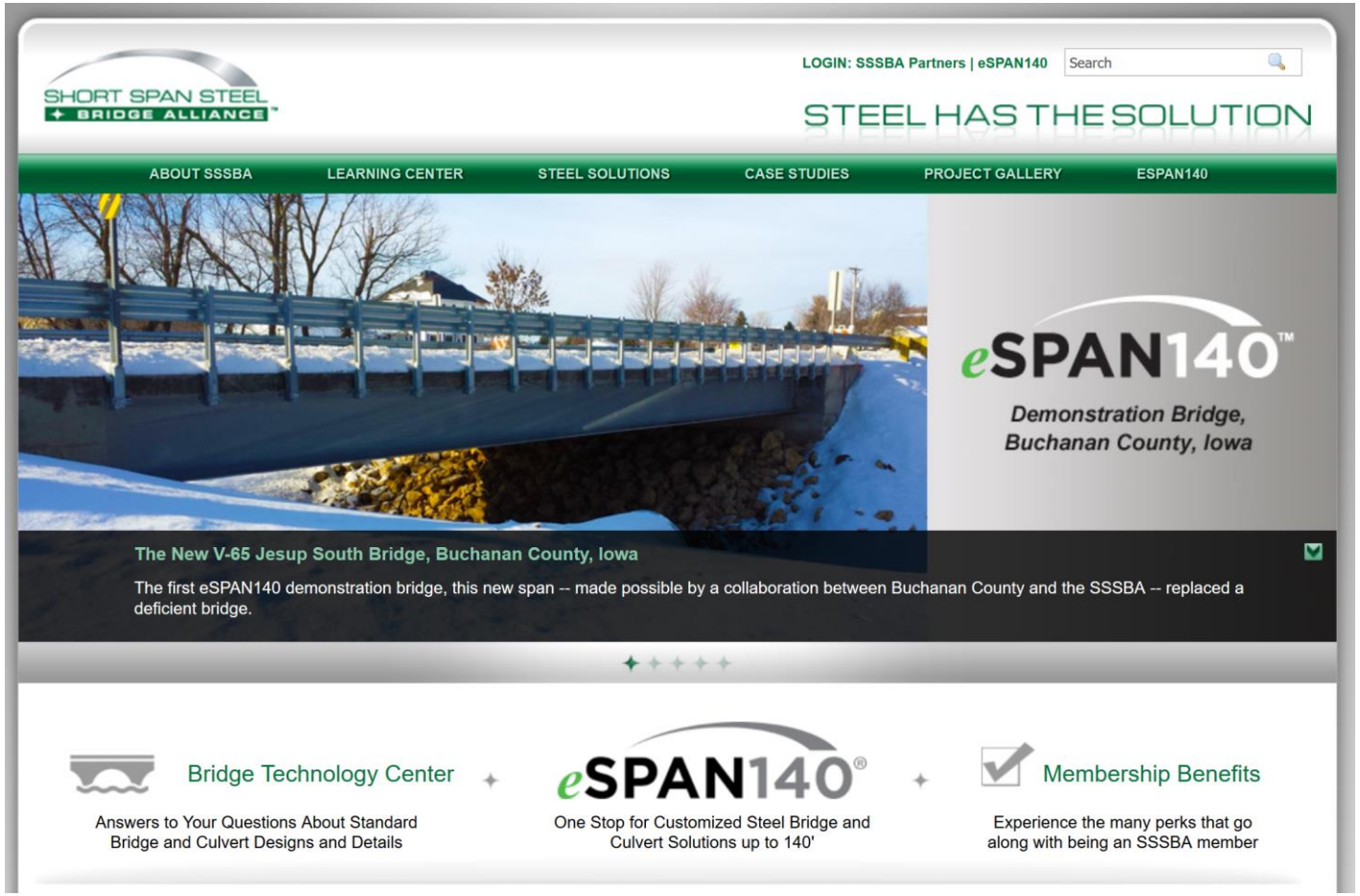
Join Today!

Rich Tavoletti (SSSBA Director)

rtavoletti@steel.org

(412) 458-5822

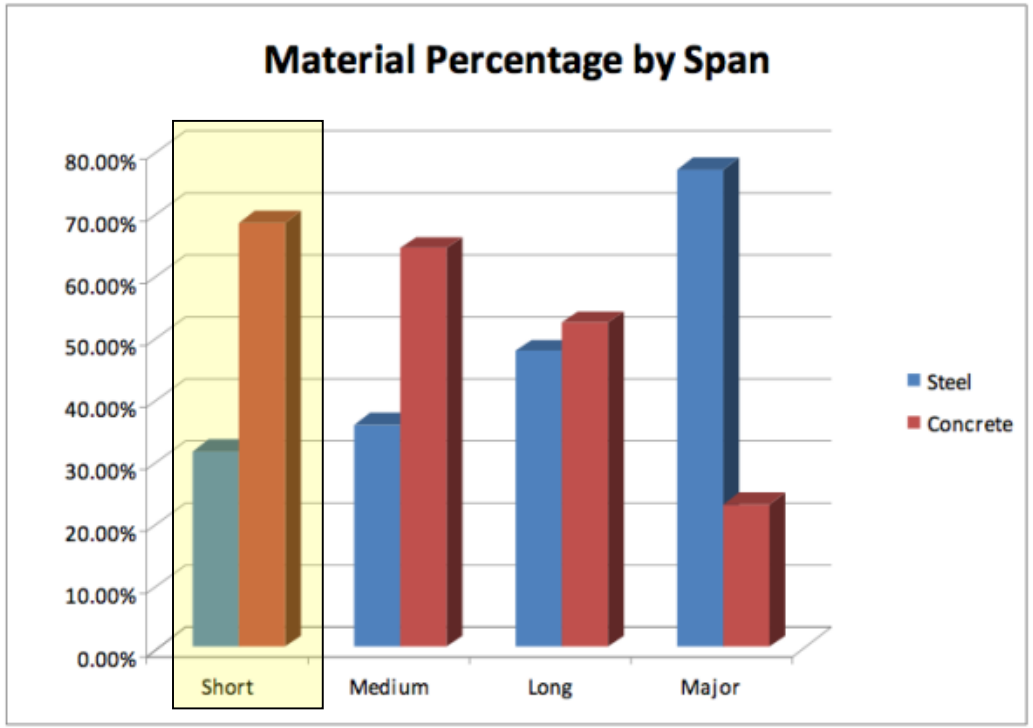
http://www.shortspansteelbridges.org/



The Problem…

- Bridge engineers are well trained on the use of short span concrete bridges.
  - In fact, over than 80% of the short span bridges in the United States are made of concrete.

- Many County and (DOT) engineers are simply not educated/familiar with the design, construction, and economics of short span steel bridges.
  - Concrete provides simple, standardized, cost-effective, “tinker toy” solutions to construct short span steel bridges.
  - Steel bridges are “perceived to be too” complex, “Swiss watch”-like, and too



Case Study Bridges: Audrain County, MO

- Project Location:

Case Study Bridges: Audrain County, MO (cont'd)

- MO Bridge 411
  - Built 2012

  - 4 Steel Girders
  - 47.5 ft Span
  - 24 ft Roadway Width
  - 2 ft Structural Depth + Slab

- MO Bridge 336
  - Built 2012

  - 6 Precast Hollowcore Slabs
  - 50.5 ft Span
  - 24 ft Roadway Width
  - 2 ft Structural Depth + Slab

Case Study Bridges: Audrain County, MO (cont'd)

- Steel:

- Concrete:

19.3% Total Cost Savings w/ Steel

– Total Bridge Costs:

- Material = $41,764
- Labor = $24,125
- Equipment = $21,521
- Guardrail = $7,895
- Rock = $8,302
- Engineering = $8,246
- TOTAL = **$111,853** ($97.48/ft²)

– Total Bridge Costs:

- Material = $67,450
- Labor = $26,110
- Equipment = $24,966
- Guardrail = $6,603
- Rock = $7,571
- Engineering = $21,335
- TOTAL = **$154,035**

Case Study Bridges: Audrain County, MO (cont'd)

- Steel:

  - Total Cost per ft^2:
    - Total Cost = $97.48/ft^2$
    - Construction = $90.29/ft^2$
      - No Engineering
    - Adjusted = $83.05/ft^2$
      - No Engineering or Rock

- Concrete:

  - Total Cost per ft^2 :
    - Total Cost = $120.83/ft^2$
    - Construction = $104.08/ft^2$
      - No Engineering
    - Adjusted = $98.14/ft^2$
      - No Engineering or Rock

Case Study Bridges: Audrain County, MO (cont'd)

- Steel:
  - Superstructure Only:
    - Start to finish = 10 days
    - Girders = $21,463
    - Deck Panels = $7999
    - Reinf. Steel = $3135
    - Concrete = $4180
    - Labor = $5522
    - Equipment* = $500
    - TOTAL = $42,799

    = $37.54 / ft²

- Concrete:
  - Superstructure Only:
    - Start to finish = 13 days
    - Slab Girders = $50,765
    - Deck Panels = $0
    - Reinf. Steel = $724
    - Concrete = $965
    - Labor = $4884
    - Equipment* = $4000
    - TOTAL = $61,338

    = $50.61 / ft²

Material Considerations:

- *Added cost to use galvanized steel ≈ $0.22/lb (includes est. 10% fabrication fee)*
- *Added cost to use weathering steel ≈ $0.04/lb (already included in cost in example)*

Equipment Considerations:

- *County crane (30-ton) used for steel; Larger rented crane required for concrete*
  - *Equivalent county crane cost is $1520 (would result in steel cost of $38.88 / ft²)*

Case Study Bridges: Audrain County, MO (cont'd)

- Steel:

  - Superstructure total cost of $37.54 per ft^2

25.8% Superstructure Cost Savings

- Concrete:

  - Superstructure total cost of $50.61 per ft^2

Same bridge conditions:

- *Structural Depth = 2 ft + Slab (No Difference in Approaches)*
- *Roadway Width = 24 ft*
- *Same Abutments for Both Can be Used (Steel Could Use Lighter)*
- *Same Guard Rail System*
- *Same Work Crew*

Advantages of MO Bridge 411

- Lighter cranes required:
  - Owner cranes can save costs.

Advantages of MO Bridge 411 (cont'd)

- Lighter abutments possible for steel bridges.

Advantages of MO Bridge 411 (cont'd)

- Cast-in-place deck on prestressed concrete deck panels

Advantages of MO Bridge 411 (cont'd)

- Simple and practical details:

Advantages of MO Bridge 411 (cont'd)

- Elastomeric bearings and integral abutments:

Advantages of MO Bridge 411 (cont'd)

- Use of weathering steel:

Case Study Bridges: Additional Bridges in MO

Superstructure	Steel						Concrete				
Bridge Number	061	140	149	152	710	AVG	028	057	069	520	AVG
Year Built	2008	2008	2008	2009	2010	AVG	2009	2010	2011	2006	AVG
Span Length	50	50	40	62	64	53.2	36	36	38	40	37.5
Skew	0	0	0	30	35	13	0	15	20	30	16.25
Cost Summary											
- Labor	$14,568	$21,705	$15,853	$24,765	$31,949	$21,768	$12,065	$15,379	$14,674	$19,044	$15,291
- Material	$56,676	$53,593	$46,282	$92,821	$69,357	$63,746	$51,589	$54,450	$50,576	$46,850	$50,866
- Rock	$6,170	$6,216	$3,694	$8,235	$6,501	$6,163	$5,135	$7,549	$5,378	$3,621	$5,421
- Equipment	$7,487	$12,026	$7,017	$19,579	$15,266	$12,275	$5,568	$10,952	$11,093	$14,742	$10,589
- Guardrail	$4,715	$7,146	$3,961	$7,003	$7,003	$5,966	$4,737	$4,663	$5,356	$3,323	$4,520
Construction Cost	$89,616	$100,686	$76,807	$152,403	$130,076	$109,918	$79,094	$92,993	$87,077	$87,580	$86,686
CONST. COST PER FT^2	$74.68	$83.91	$80.01	$102.42	$84.68	$86.09	$91.54	$107.63	$95.48	$91.23	$96.32

The Solution

- Standardized designs for short span steel bridges
  - BTC led a 3-year industry-wide effort (owners, fabricators, designers, associations, service centers, etc. involved)
    - Over 3,000 designs evaluated
  - Result = simple standardized designs for short span bridges
    - Rolled beam, plate, & buried soil steel structures
  - Standards used to develop eSPAN140
    - 650 total preliminary bridges designed
    - Adding abutments, substructure, CSP enhancements, metric, and Canadian designs in next 12 months.
  - BTC working with Mexico & Canada to develop MEX/CAN version
  - BTC working with AASHTO for designs to become a national guideline

eSPAN140™

http://www.espan140.com/

Free Online Design Tool for Short Span Steel Bridges

Utilizes Standard Short Span Steel Bridge Designs

SHORT SPAN STEEL BRIDGE DESIGN STANDARDS

Standards for Short Span Steel Bridge Designs

- Goals:
  - Economically competitive
  - Expedite & economize the design process
  - Simple repetitive details & member sizes.
- Bridge Design Parameters:
  - Span lengths: 40 feet to 140 feet (5-foot increments)
  - Girder spacing: 6 feet, 7.5 feet, 9 feet and 10.5 feet
  - For each of these increments, the following were design
    - Steel girders
    - Shear stud & stiffener layouts
    - Welding and fabrication details
    - Elastomeric bearings
    - Concrete deck design

Primary value is use as an estimating tool!

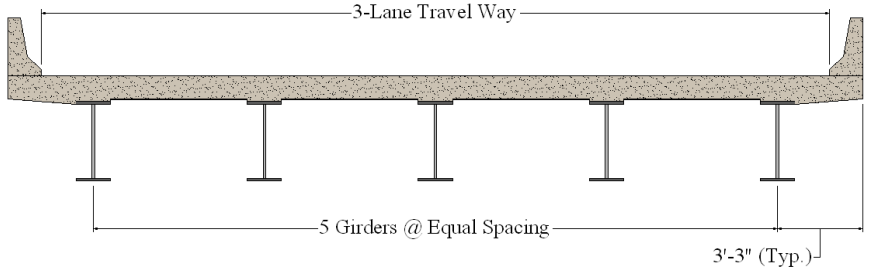
- Now have the ability to produce a valid steel bridge design in minutes
- Obtain a cost estimate from a fabricator within a day
- Can directly compete with concrete alternate
- Design can then be further optimized

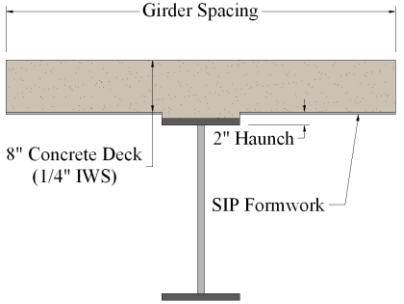
Standard Short Span Steel Bridge Designs (cont'd)

- Four types of girder types:
  - Homogeneous plate girders (50 ksi steel)
  - Hybrid plate girders
    - 50 ksi top flanges and webs, 70 ksi bottom flanges
  - Lightest weight rolled beams (50 ksi steel)
    - Utilizing the lightest weight girder necessary
  - Limited depth rolled beams (50 ksi steel)
    - Designed to meet a target L/D of 25
- In addition, girders were designed to accommodate commonly stockpiled plate thicknesses and rolled beam sizes.

Standard Short Span Steel Bridge Designs (cont'd)

- Bridges were designed according to AASHTO LRFD Specs:
  - Strength I, Service II, Fatigue, Constructability, L/800 Deflection
  - HL-93 Vehicular Live Loading
- Additional Design Loads:

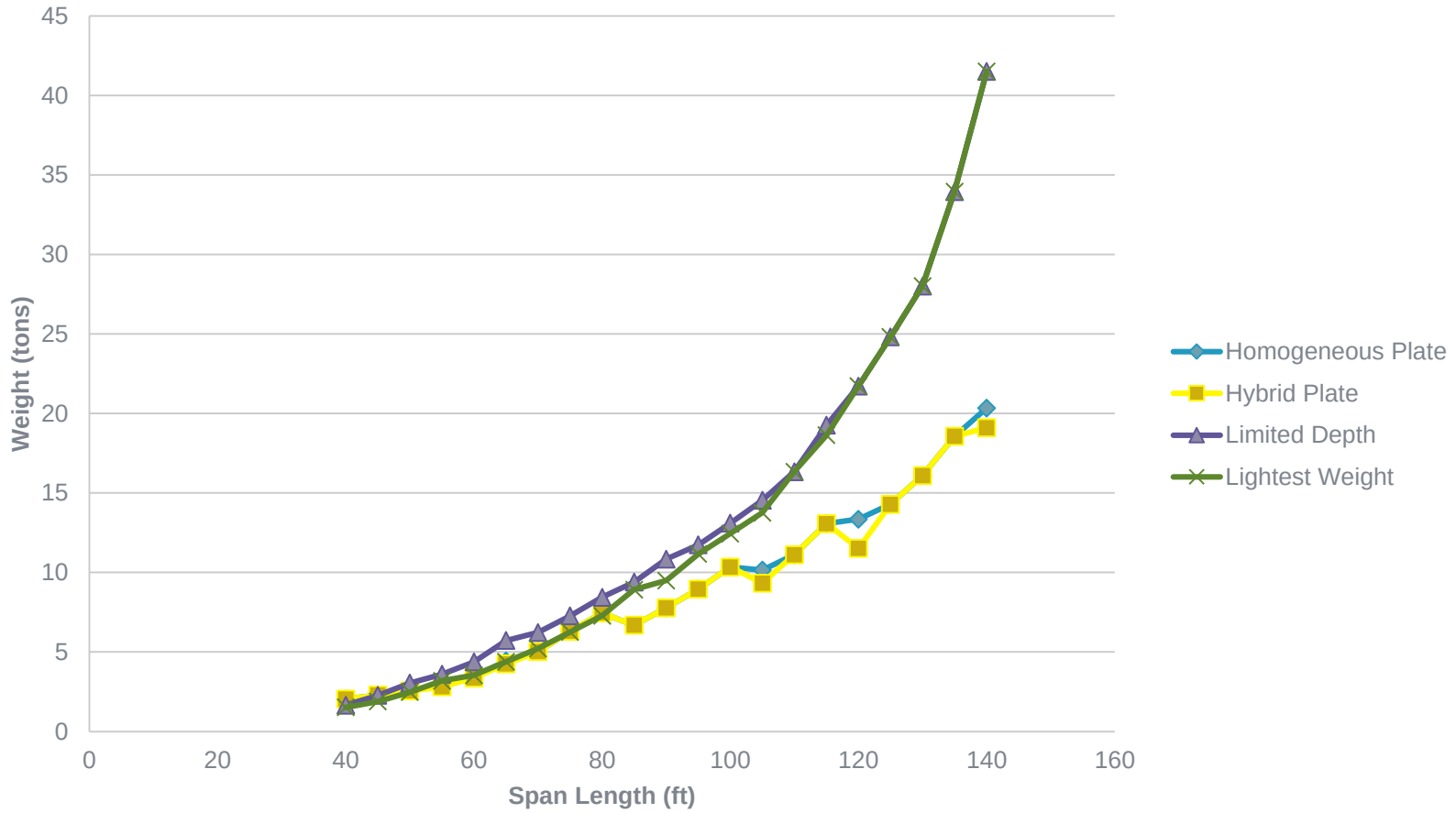




  - SIP unit weight: 15 psf
  - FWS: 25 psf
  - Concrete barriers = 520 lb/ft
  - Misc. steel wt. increase = 5%
  - Concrete unit weight = 150 pcf
  - Steel unit weight = 490 pcf
  - Concrete haunch = 2 in
  - Constant flange width
  - Constant web height

Standard Short Span Steel Bridge Designs (cont'd)

- Weight comparisons (9'-0" girder spacing):



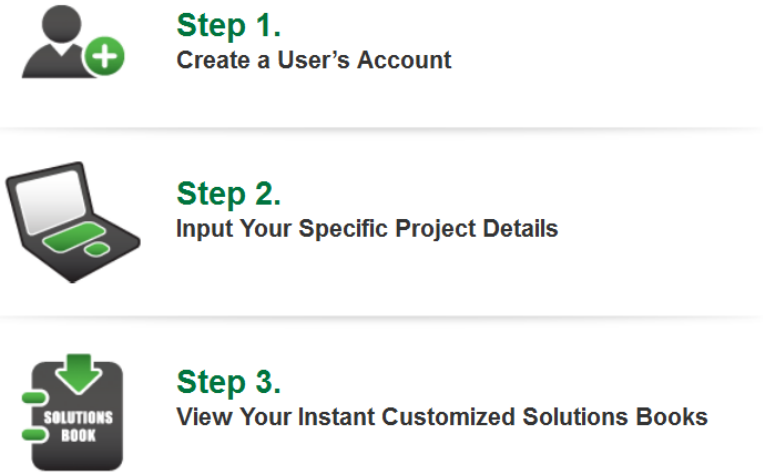
eSPAN140

One-stop shop for customized steel bridge and culvert solutions!

Free and easy to use!!!

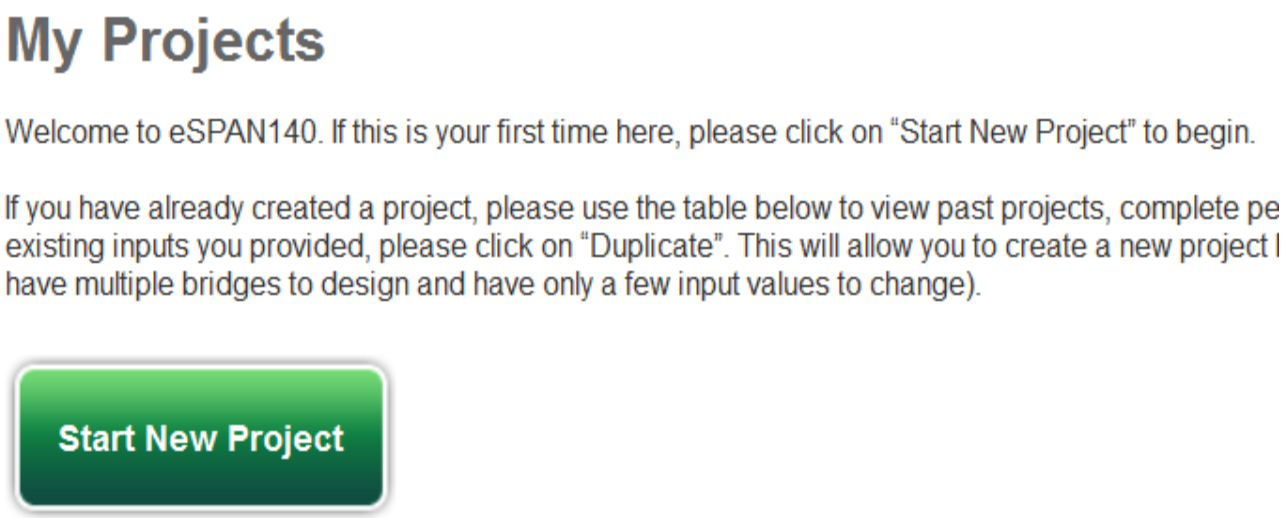
http://www.espan140.com/

- eSPAN140 provides:
  - Standard designs and details for short span steel crossings
    - Rolled Beam and Plate Girders
    - Corrugated Steel Pipe and Structural Plate
  - Manufacturers' Steel Solutions (SSSBA Partners)
  - Coatings Solutions
  - Industry Contacts
    - Contacts can provide budget estimates and pricing information



eSPAN140 Example

- Start new project:



eSPAN140 Example (cont'd)

- Step 1: Project Information

Project Name*
Sample Bridge

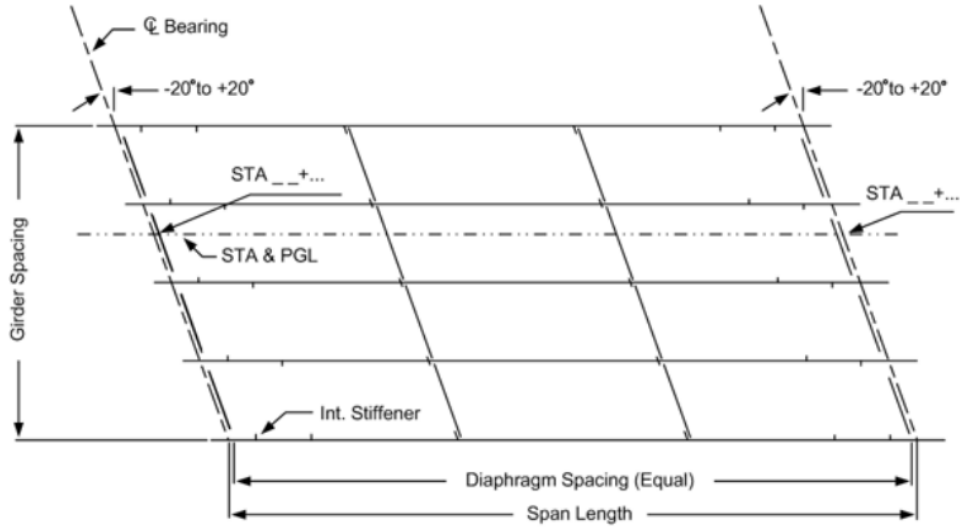
City/County*
Morgantown

State/Province*
West Virginia

Roadway Name
Main Street

Bridge Span Length*
82 Feet
4 Inches

Next > Return to Projects



eSPAN140 Example (cont'd)

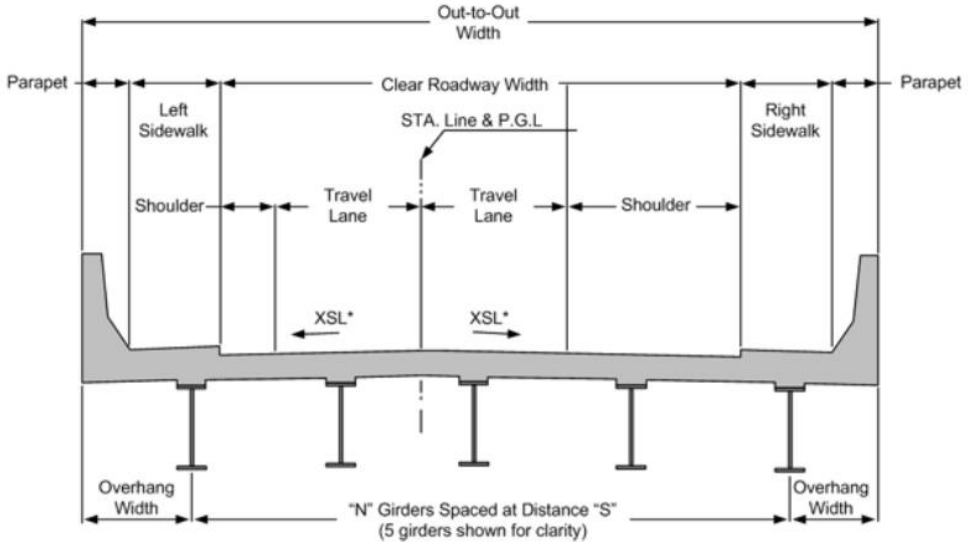
- Step 2: Project Details (general dimensions)

# of Striped Traffic Lanes*
2

Roadway Width*
30 Feet 0 Inches

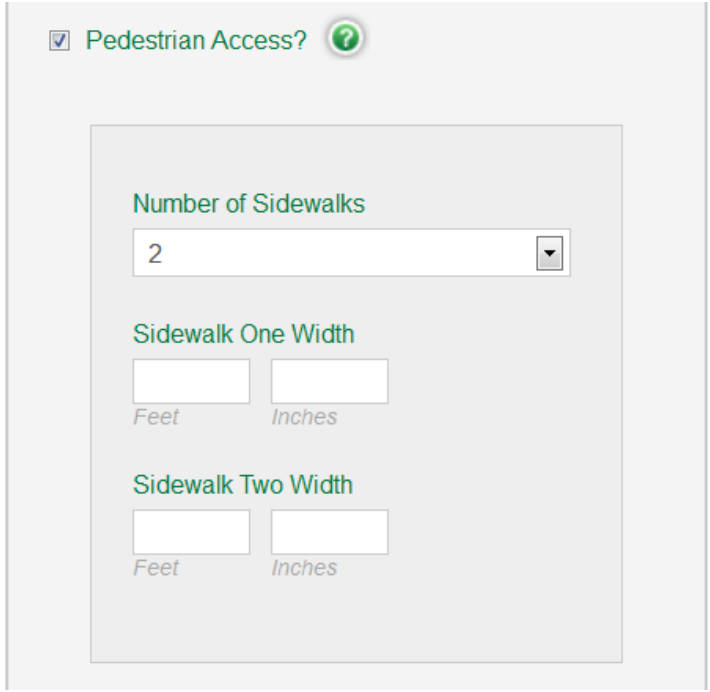
Individual Parapet Width
1 Feet 3 Inches

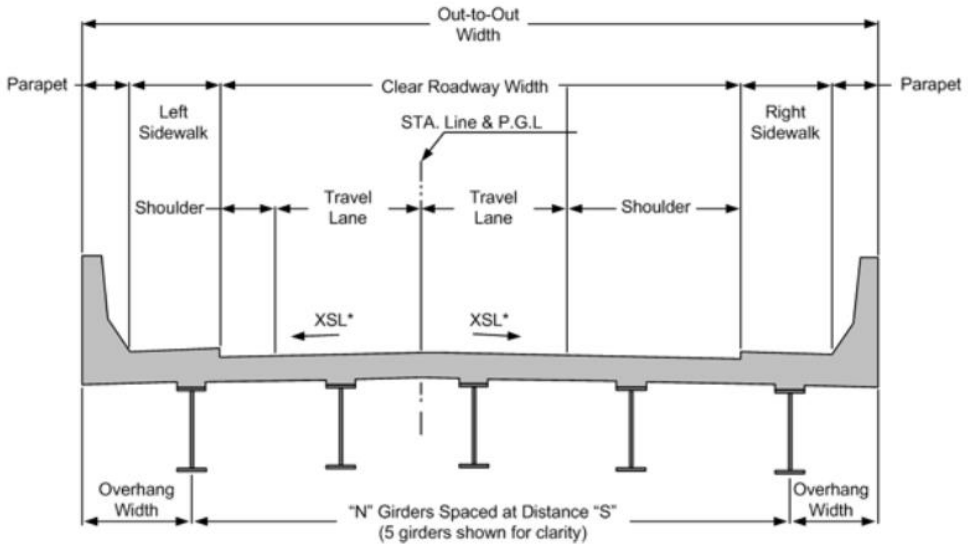
Individual Deck Overhang Width
3 Feet 0 Inches



eSPAN140 Example (cont'd)

- Step 2: Project Details (pedestrian access option)





eSPAN140 Example (cont'd)

- Step 2: Project Details (remaining details)

Skew Angle

15

Degrees

Average Daily Traffic

Over 2,000

Design Speed

Not applicable

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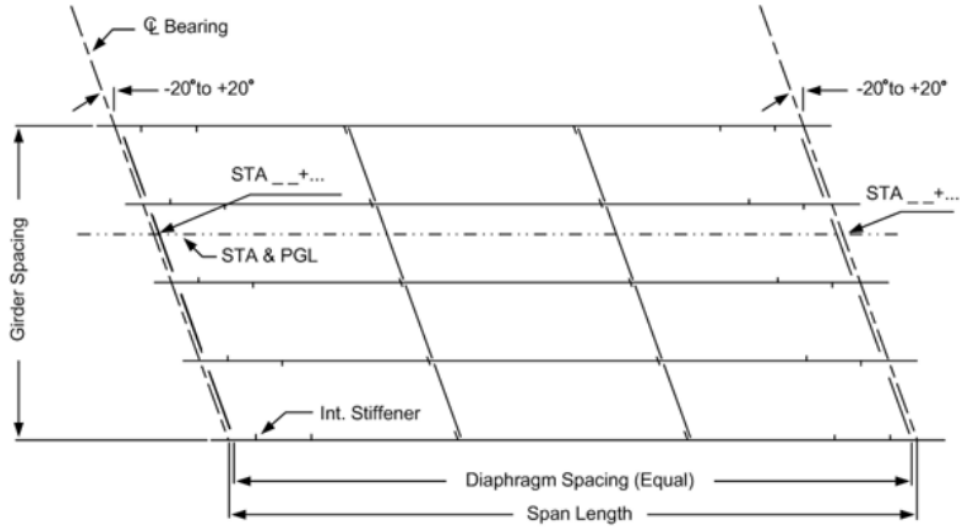
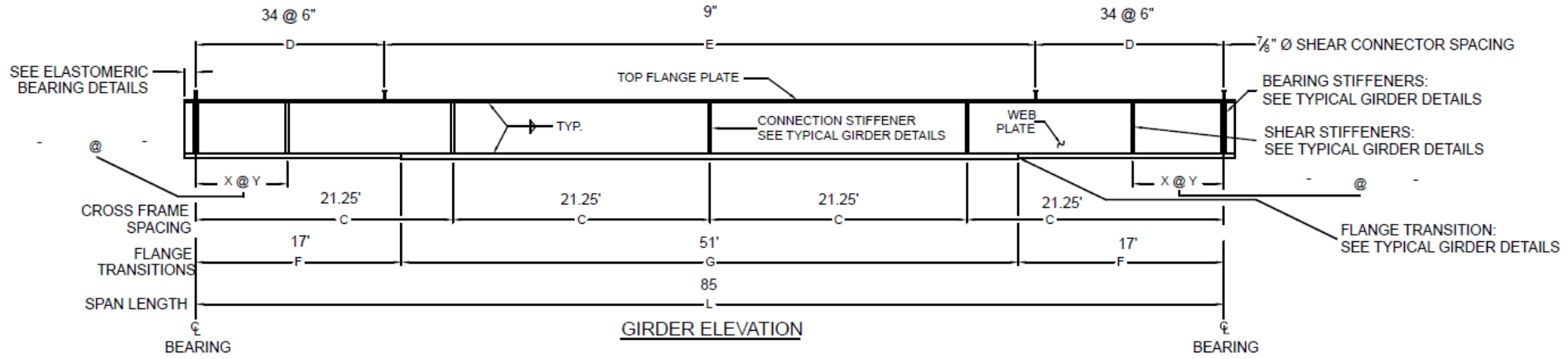


eSPAN140 Example (cont'd)

- Example output (sample plate girder elevation):

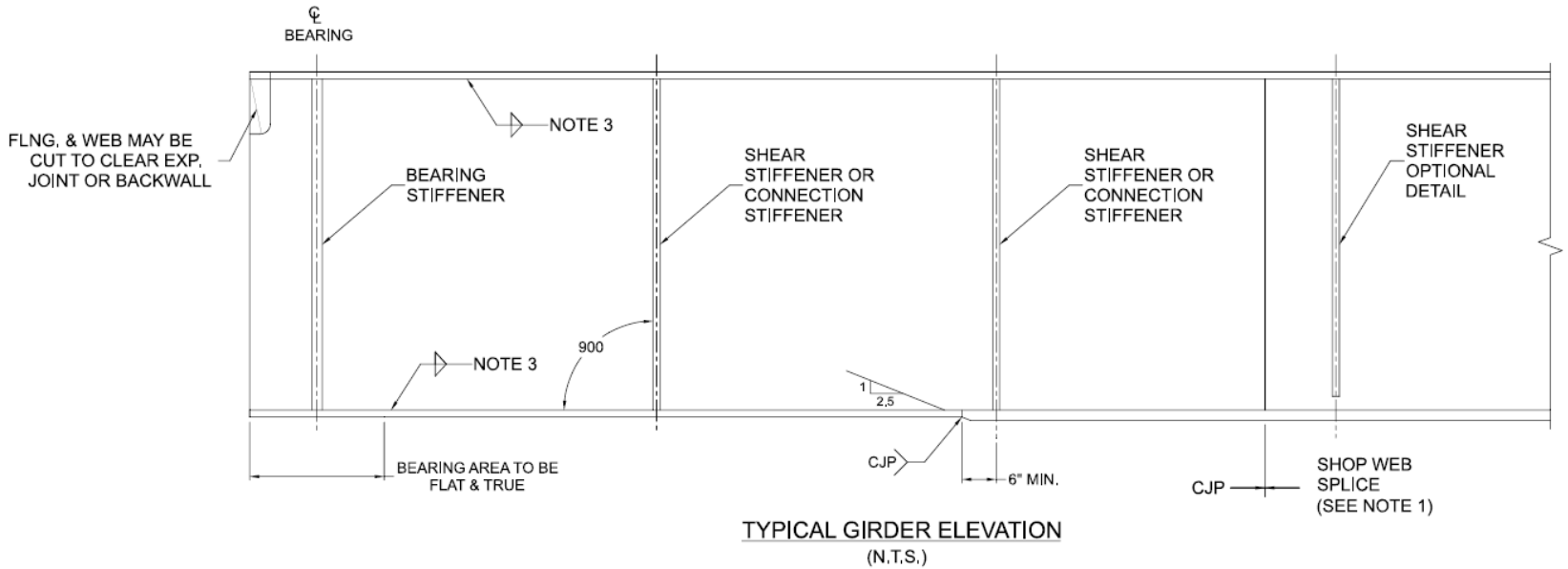
COMPOSITE PLATE GIRDER WITH PARTIALLY STIFFENED WEB - 4 GIRDERS AT 8' 10" GIRDER SPACING, HOMOGENEOUS



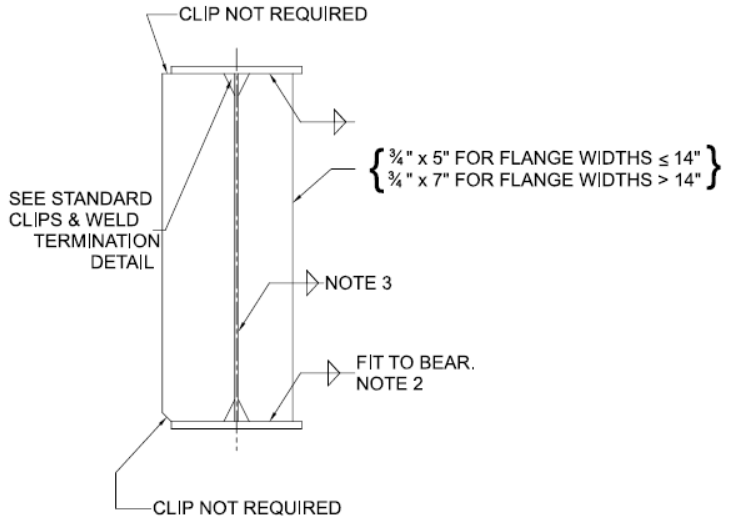
SPAN (L) - ft	PLATE GIRDER SIZE						DIAPHRAGM SPACING (C) - ft	SHEAR STIFFENERS		SHEAR CONNECTOR MAX. SPACING		INDIVIDUAL GIRDER WEIGHT
	TOP FLANGE - in	BOTTOM FLANGE (F)		BOTTOM FLANGE (G)		WEB PLATE- in		X (NO. REQ'd)	Y - ft. (SPACING)	D	E	
		PLATE - in	LENGTH - Ft	PLATE - in	LENGTH - Ft							
85	14 x 3/4"	14 x 1"	17'	14 x 2"	51'	32 x 1/2"	21.25'	-	-	34 @ 6"	9"	14,144 lbs

eSPAN140 Example (cont'd)

- Example output (typical fabrication details):



TYPICAL GIRDER ELEVATION
(N.T.S.)

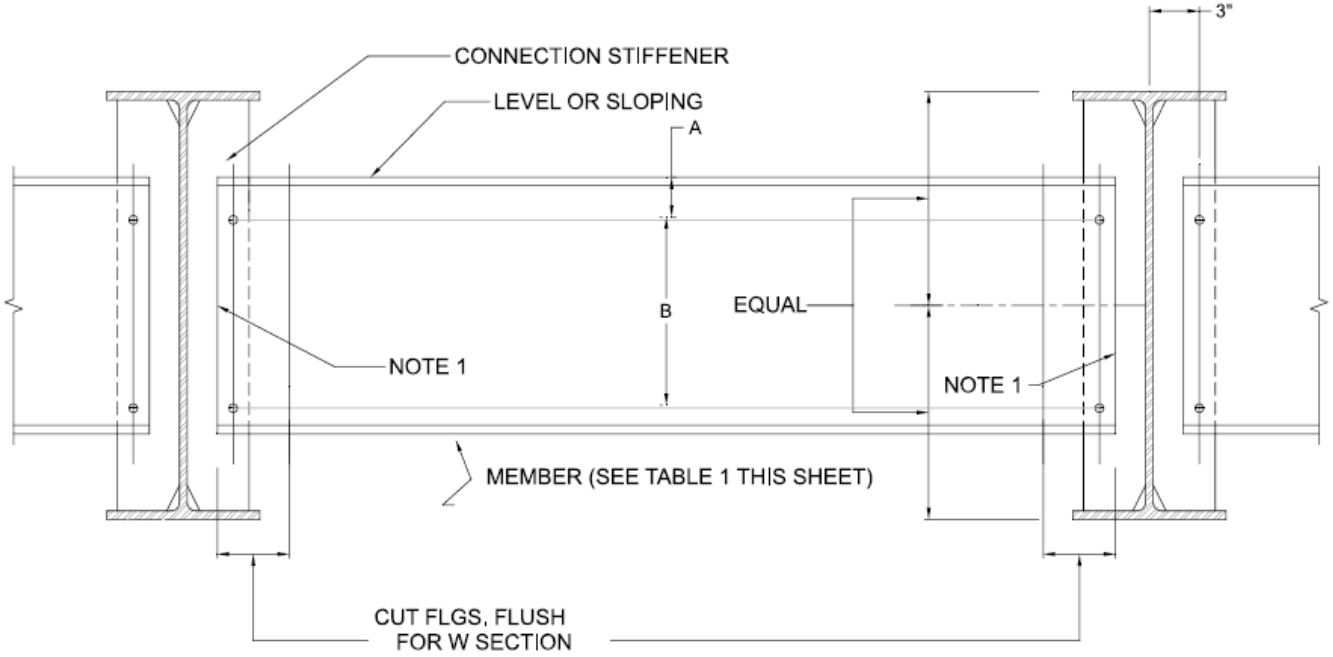


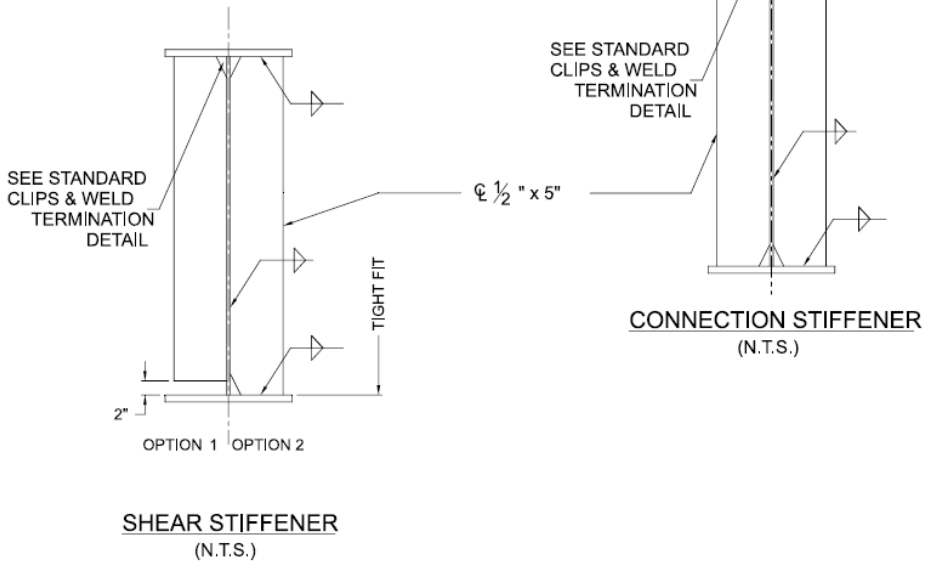
BEARING STIFFENER
(N.T.S.)

BEARING STIFFENER TO FLANGE WELDING IS REQUIRED IF A DIAPHRAGM OR CROSS FRAME IS ATTACHED TO THE STIFFENER

eSPAN140 Example (cont'd)

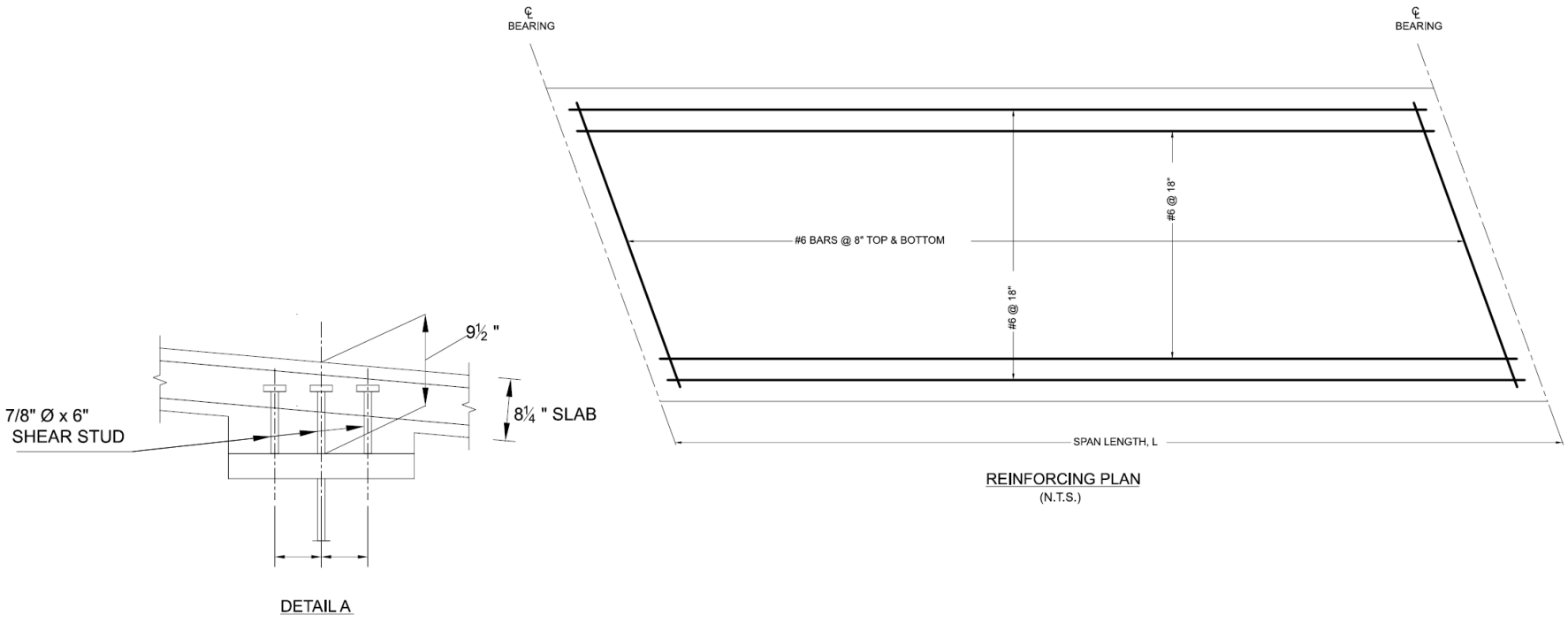
- Example output (typical fabrication details, cont'd):





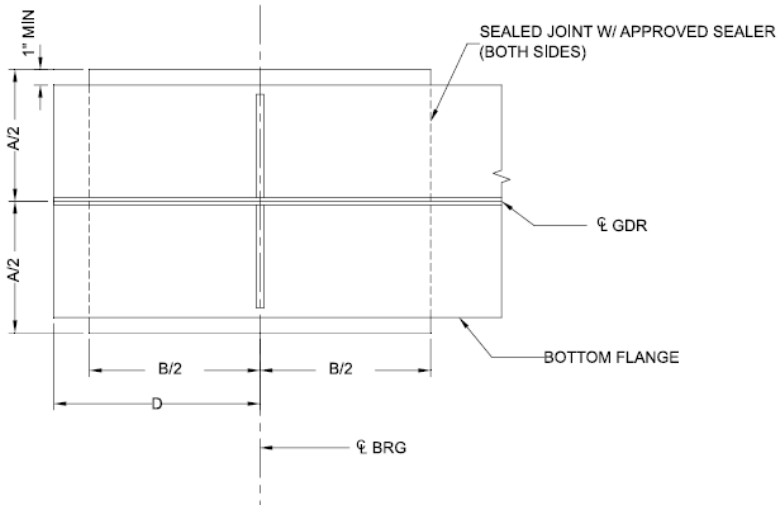
Design Example (cont'd)

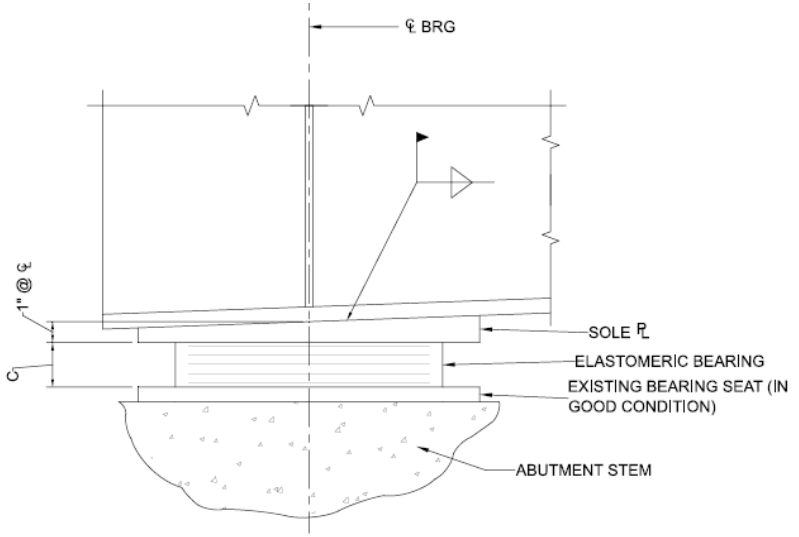
- Typical section & deck details:



Design Example (cont'd)

- Typical bearing details:



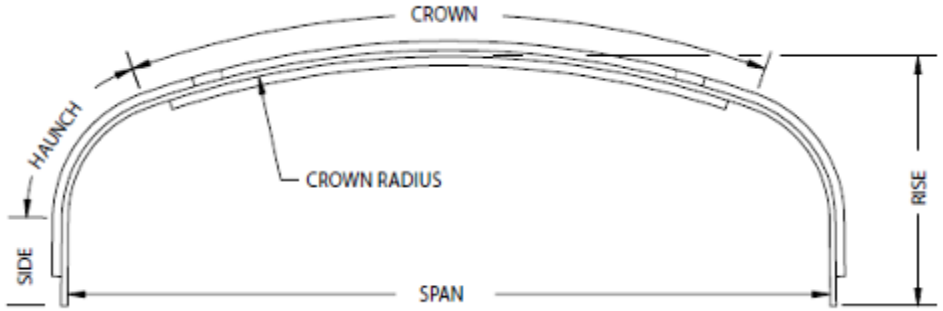


BEARING ELEVATION
OPTION "A"
(N.T.S.)

ELASTOMETRIC BEARING DETAILS - in					
A	B	C	D	INTERNAL ELASTOMER LAYERS	
				NO. OF LAYERS	THICKNESS - in
16"	18"	4.375"	12"	5	0.625"

Design Example (cont'd)

- CSP & Structural Plate Standards:



Design Example (cont'd)

- Manufacturer's Solutions:







Design Example (cont'd)

- Durability Solutions:
  - Weathering steel
  - Galvanized steel
  - Painted steel

Applications of eSPAN140

- Jesup South Bridge, Buchanan County, Iowa – 1st Direct Application
  - Buchanan County Iowa – Constructed with County Crew
  - Replacement using W36x135 rolled beams
  - 65 feet length, 40 width
  - Over $100,000 donations from members
  - Better Roads (February 2014)

Ohio Short Span Steel Bridge Design Standards

- In light of the success of eSPAN140, the Bridge Technology Center has been engaged in efforts to generate eSPAN140-based standards approved in a given state.
  - Recent efforts have been focused on in the State of Ohio.
- The Short Span Steel Bridge Alliance has begun the development of Ohio-specific short span steel bridge design standards.
  - We are eager to assist other agencies in the development of owner-specific short-span steel bridge standards!

Bridge Technology Center

- Free resource available to bridge owners and designers with questions related to:
  - Standard design and details of short span bridges (plate & rolled beam)
  - Standard design and details of corrugated steel pipe and structural plate.

Bridge Technology Center (cont'd)

- Training & Education Available!
  - Topics
    - Bridge Engineering-101
    - Steel bridge economy & cost-effective design
    - Standard designs (rolled beam, plate, CSP, structural plate
    - Case studies/cost analysis
  - Format
    - Half-day workshops (county engineers/LTAPs)
    - Webinars (online training / presentations)
    - Steel Bridge Forums (DOTs)
    - Conferences/Trade show presentations
    - Technical Design Support (Bridge Technology Center)
    - SSSBA Website (Solutions Center, videos, etc.)

Rich Tavoletti

Steel Market Development Institute

rtavoletti@steel.org

Website:
http://www.shortspansteelbridge.org/

Short Span Steel Bridge Alliance – SSSBA

@ShortSpanSteel

Questions?

Thank You!