Development of Economical Short-Span Steel Bridge Standards

2015 Ohio Bridge Conference

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COUNTY ENGINEERS ASSOCIATION OF OHIO

"ALL TRAVEL STARTS AND ENDS ON A LOCAL ROAD"

Short-Span Steel Bridge Alliance

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 (possibly more in Mexico and Canada) are made of concrete.

- **County and Department of Transportation (DOT) engineers are simply not educated on the design, construction, and economics of short span steel bridges.**

The Problem (cont'd)

- Concrete provides simple, standardized, cost-effective, "tinker toy" solutions to construct short span steel bridges.

- **Steel bridges are too complex, "Swiss watch"-like, and too expensive.**

Case Study Bridges: Audrain County, MO

- 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

- 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**
- Concrete:
  - 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

- 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 = $120.82/ft^2$
    - Construction = $104.08/ft^2$
      - No Engineering
    - Adjusted = **$98.14/ft^2$**
      - No Engineering or Rock

Case Study Bridges: Audrain County, MO

- 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 / ft^2
- 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 / ft^2

**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 / ft^2)*

Case Study Bridges: Audrain County, MO

- Steel:
  - Superstructure total cost of $37.54 per ft^2
- Concrete:
  - Superstructure total cost of $50.61 per ft^2

Cost increase of 35%

- 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 Steel Bridge (MO Bridge 411)

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

Advantages of Steel Bridge (MO Bridge 411)

- Lighter abutments possible for steel bridges.

Advantages of Steel Bridge (MO Bridge 411)

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

Advantages of Steel Bridge (MO Bridge 411)

- Simple and practical details:

Advantages of Steel Bridge (MO Bridge 411)

- Elastomeric bearings and integral abutments:

Advantages of Steel Bridge (MO Bridge 411)

- Use of weathering steel:

Case Study Bridges: Other 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**

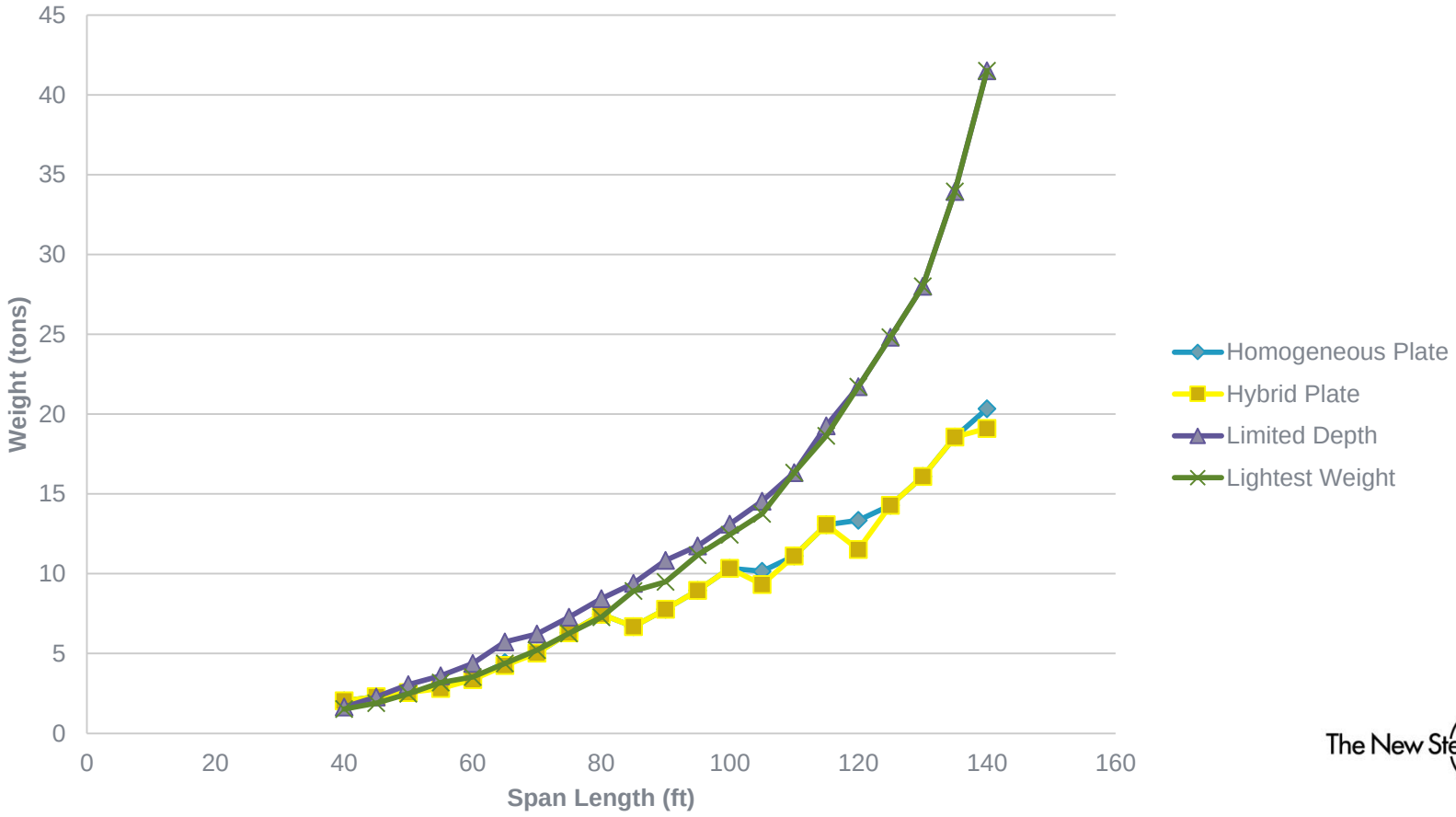
The Solution – Product Development

- **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

Standard Short Span Steel Bridge Designs

- Goal:
  - Economically competitive
  - Expedite and economize the design process
  - Simple repetitive details and member sizes.
- Bridge Parameters:
  - Span lengths: 40 ft to 140 ft (in 5 ft increments)
  - Girder spacing: 6 ft, 7.5 ft, 9 ft and 10.5 ft
  - Homogeneous and hybrid plate girders with limited plate sizes
  - Limited depth and lightest weight rolled sections
  - Selective cross-frame placement & design

Weight Comparisons



The New Steel

SHORT SPAN STEEL BRIDGE ALLIANCE

STEEL HAS THE SOLUTION

eSPAN140

Free Online Design Tool for
Short Span Steel Bridges

Developed by the Short Span Steel Bridge Alliance

http://www.espan140.com/

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SHORT SPAN STEEL BRIDGE ALLIANCE

STEEL HAS THE SOLUTION

eSPAN140

One-stop shop for customized steel bridge and culvert solutions located at 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

The New Steel

eSPAN140

- eSPAN140 is an easy-to-use and **free** resource for bridge engineers & owners.

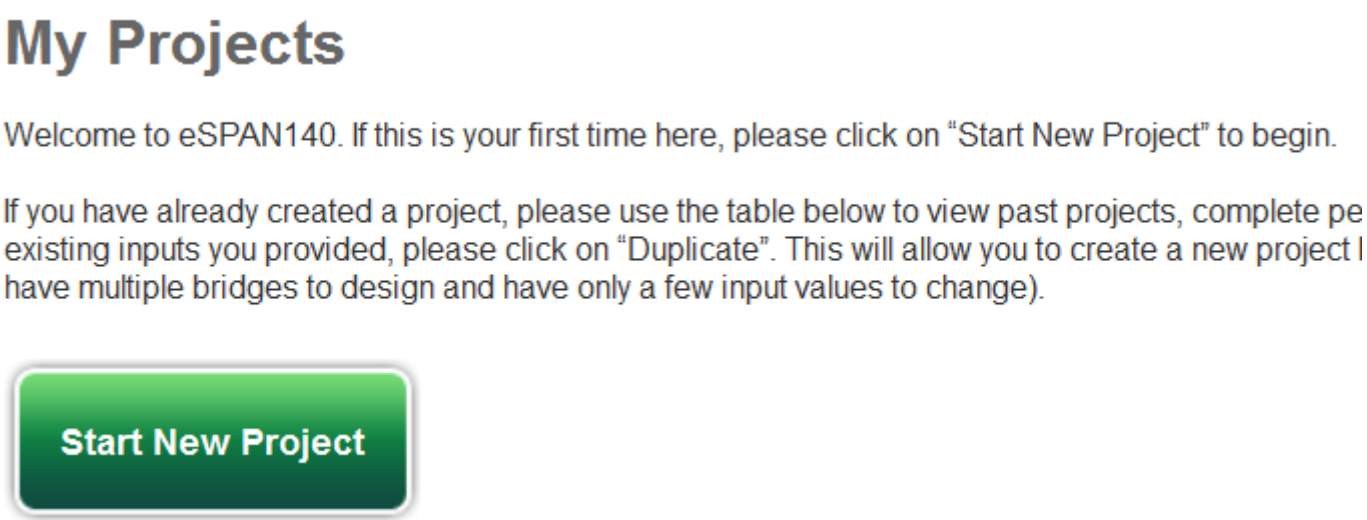
- In 3 easy steps, multiple steel solutions are recommended!

Step 1.
Create a User's Account

Step 2.
Input Your Specific Project Details

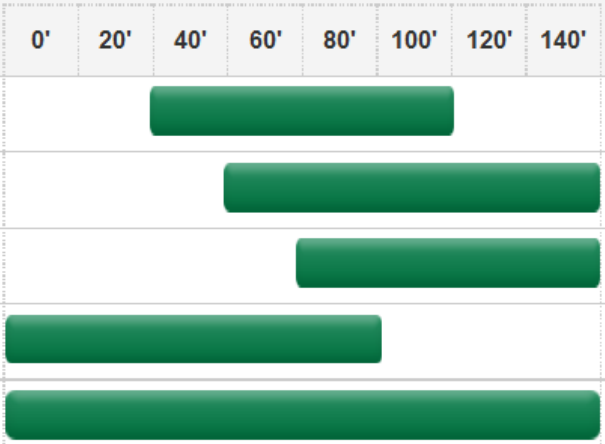
Step 3.
View Your Instant Customized Solutions Books

- Start new project:



- Range of available solutions:

Solution Type*	Bridge Span Length	Skew Angle	Overhang Width
Rolled Beam (40' to 100')**		+/- 20 degrees	3'3" or less
Homogeneous Plate Girder (60' to 140')**		+/- 20 degrees	3'3" or less
Hybrid Plate Girder (80' to 140')**		+/- 20 degrees	3'3" or less
Corrugated Steel Pipe/Structural Shape (0' to 85')		All	All
Manufacturer's Steel Solutions (all)		All	All



- 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

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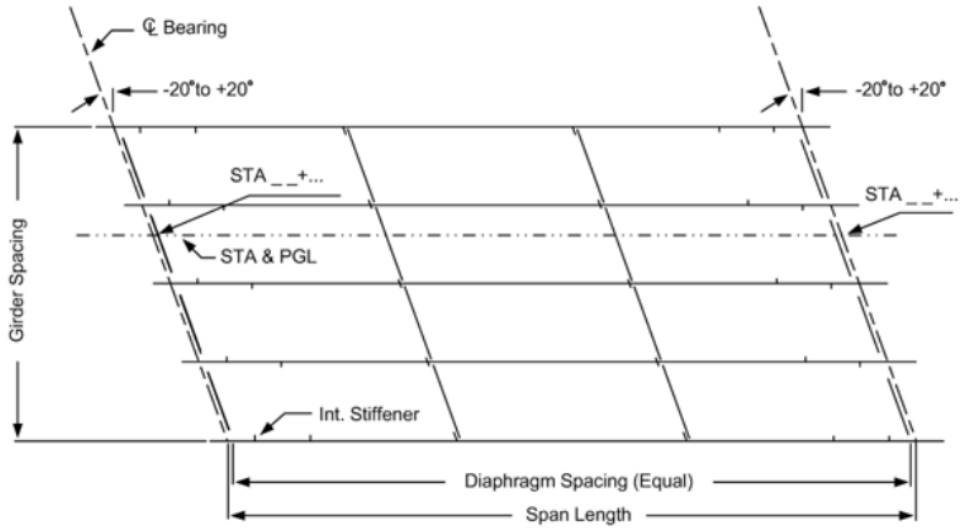

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- Step 2: Project Details (general dimensions)

# of Striped Traffic Lanes*

2

Roadway Width*

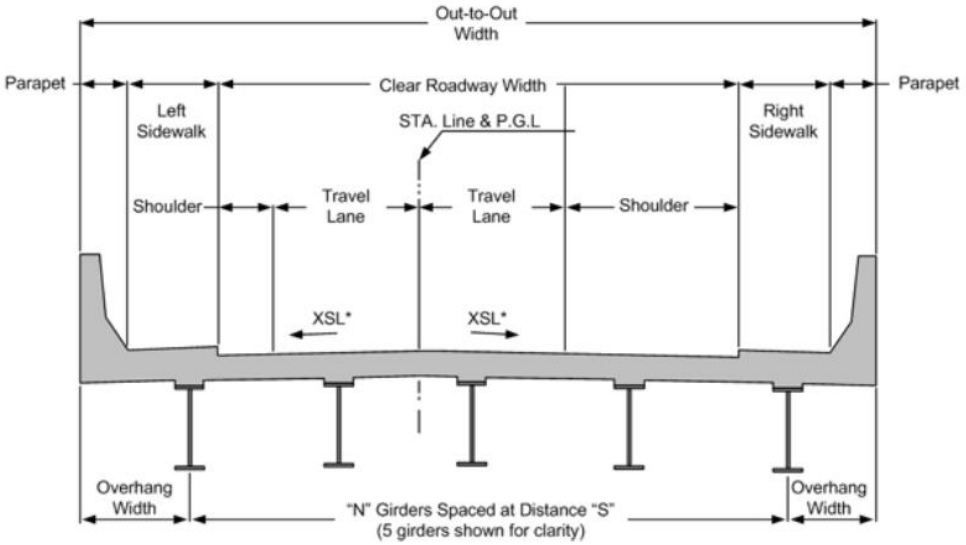
30 Feet 0 Inches

Individual Parapet Width

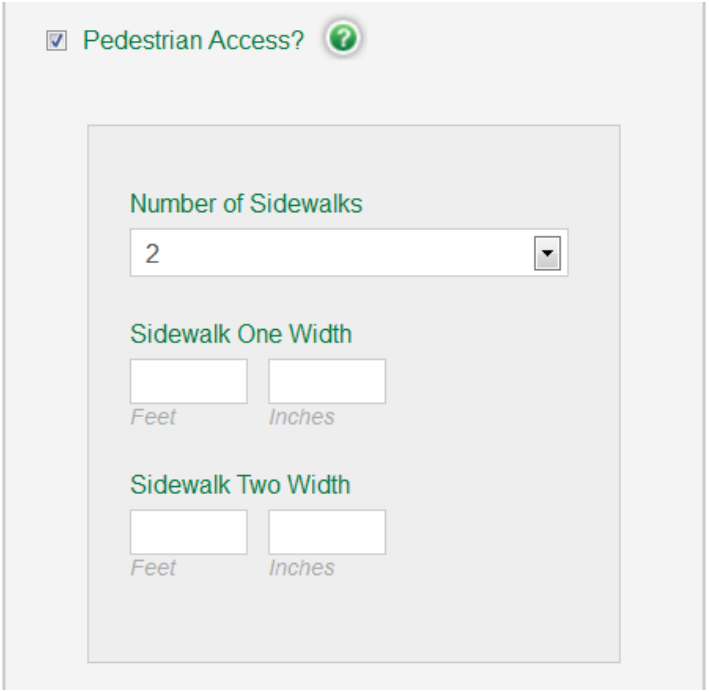
1 Feet 3 Inches

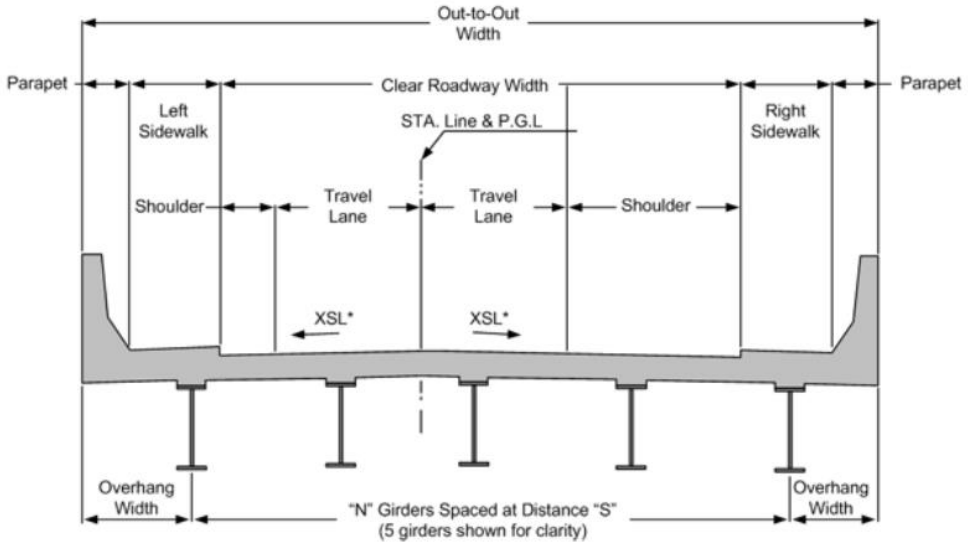
Individual Deck Overhang Width

3 Feet 0 Inches



- Step 2: Project Details (pedestrian access option)





- Step 2: Project Details (remaining details)

Skew Angle

15

Degrees

Average Daily Traffic

Over 2,000

Design Speed

Not applicable

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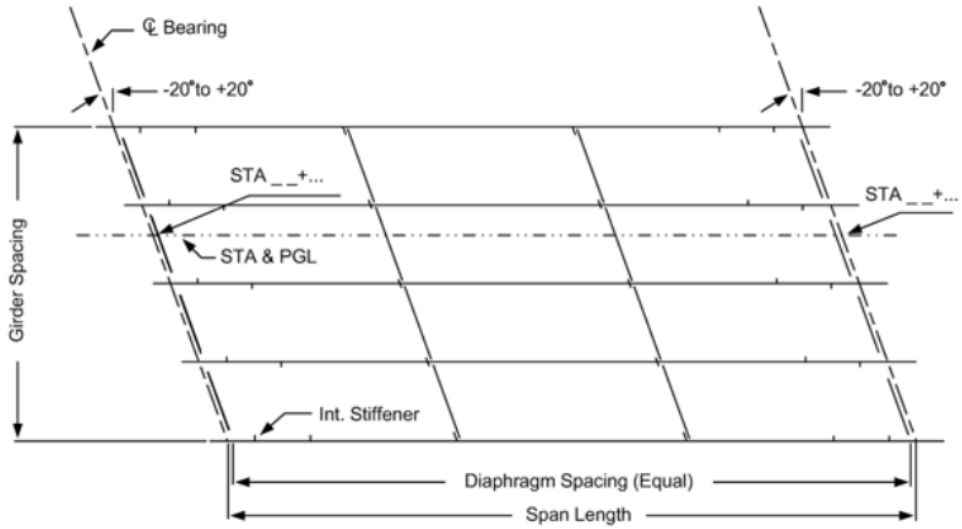


- Step 3: Customized Solutions Book is Provided (pdf)

Standard Design and Details of Short Span Steel Bridges Solutions
- Rolled Beam Recommendations
- Plate Girder Recommendations

Standard Design and Details of Corrugated Steel Pipe and Structural Plate Solutions

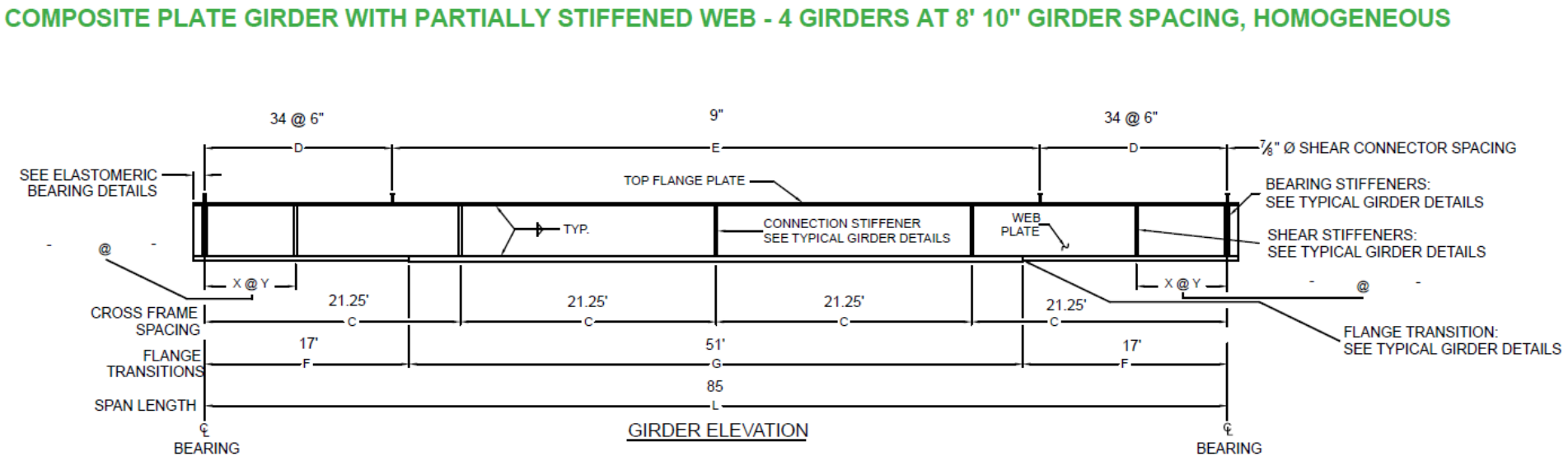
Manufacturer's Steel Solutions (SSSBA Partners)
- Customized Solutions from Members of the SSSBA

Durability Solutions (SSSBA Partners)
- Galvanized & Paint
- Weathering Steel

Additional Contact Information
- Producers
- Service Centers
- Fabricators
- Fasteners
- Coaters
- Industry Organizations

Design Example

- Sample plate girder (homogeneous) elevation:



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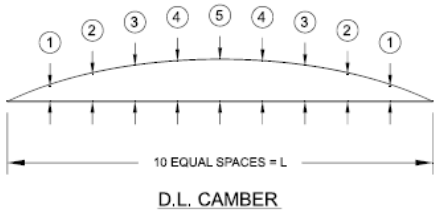
Design Example

- Sample plate girder (homogeneous) data:

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

STEEL D.L. CAMBER - in					TOTAL D.L. CAMBER - in				
1	2	3	4	5	1	2	3	4	5
0.251"	0.469"	0.636"	0.742"	0.778"	1.803"	3.358"	4.538"	5.288"	5.545"



D.L. CAMBER

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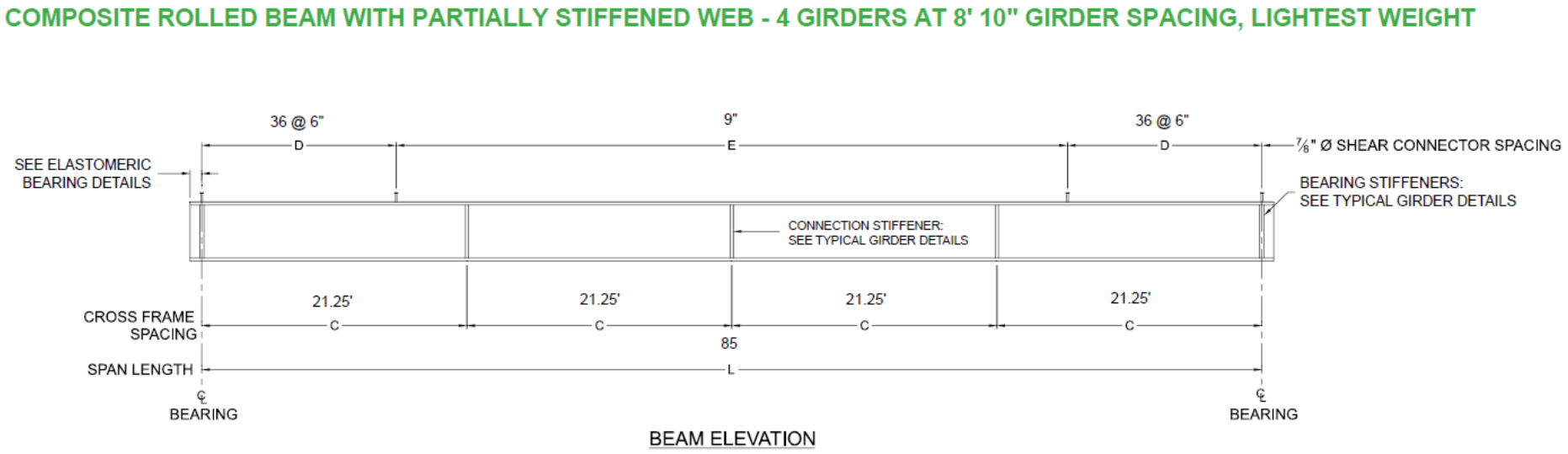
Design Example

- Sample rolled beam (lightest weight) elevation:

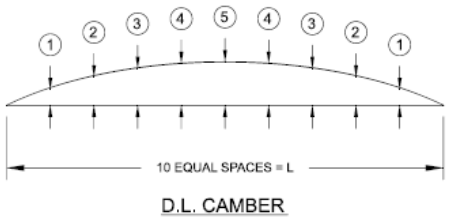


Design Example

- Sample rolled beam (lightest weight) data:

SPAN (L) - ft	SELECTED SECTIONS	DIAPHRAGM SPACING (C) - ft	SHEAR CONNECTOR MAX. SPACING		WEIGHT
			D	E	
85	W36x247	21.25'	36 @ 6"	9"	20,995 lbs

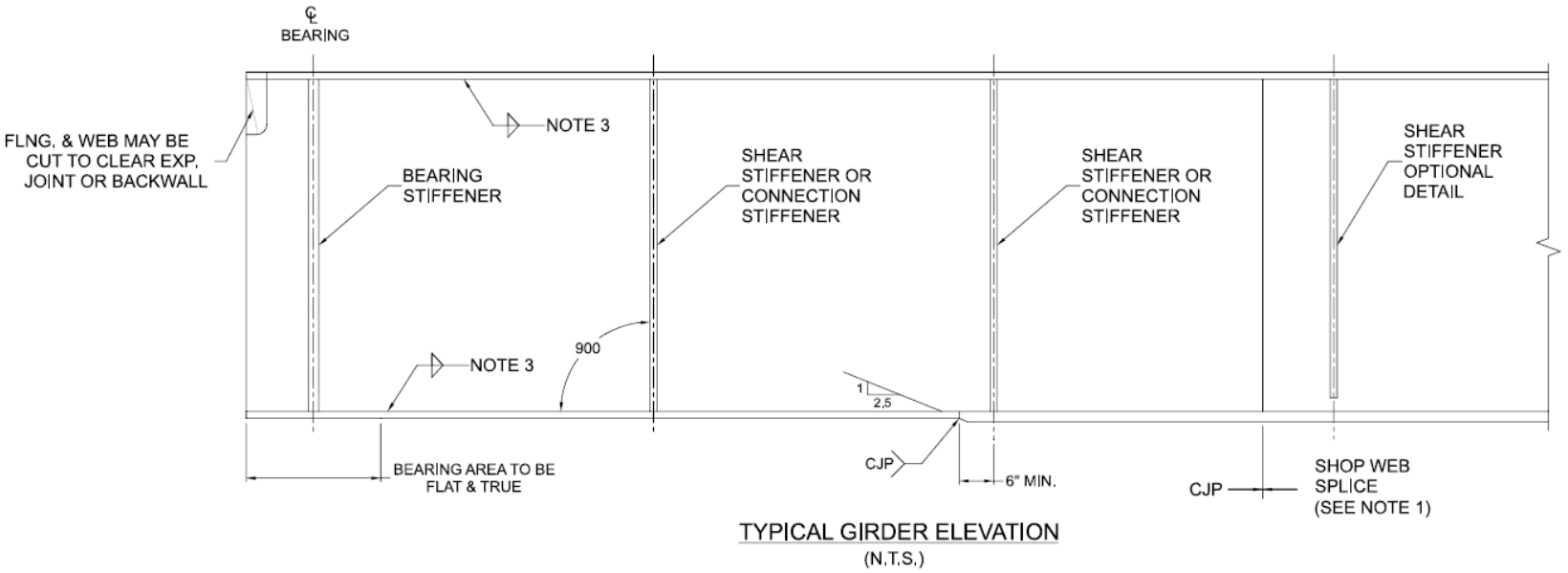
STEEL D.L. CAMBER - in					TOTAL D.L. CAMBER - in				
1	2	3	4	5	1	2	3	4	5
0.219"	0.415"	0.568"	0.665"	0.698"	1.259"	2.381"	3.259"	3.817"	4.008"



D.L. CAMBER

Design Example

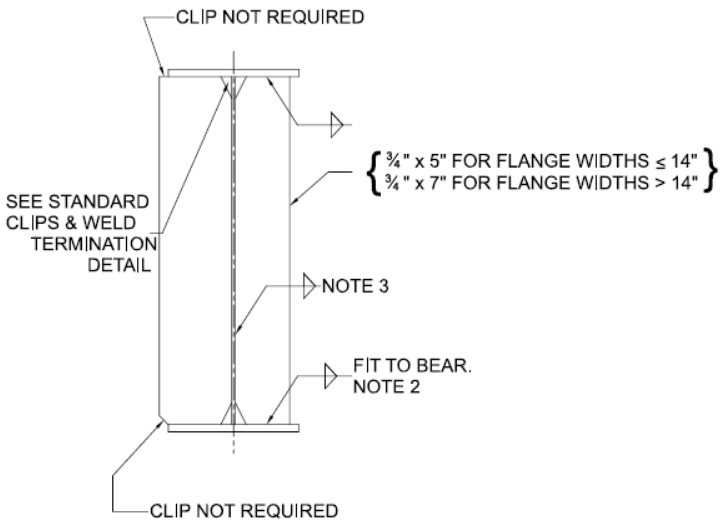
- Typical girder elevation:



TYPICAL GIRDER ELEVATION
(N.T.S.)

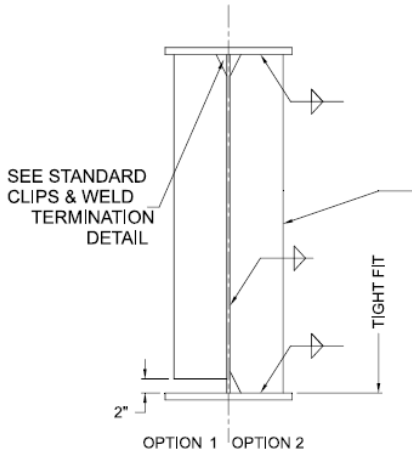
Design Example

- Typical stiffener details:

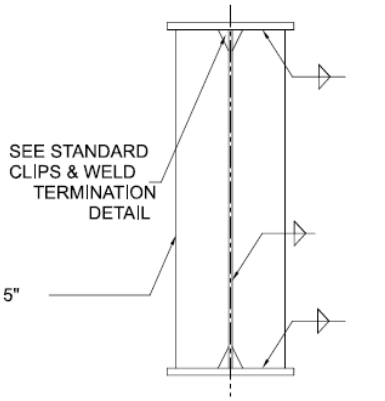


BEARING STIFFENER
(N.T.S.)

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



SHEAR STIFFENER
(N.T.S.)



CONNECTION STIFFENER
(N.T.S.)

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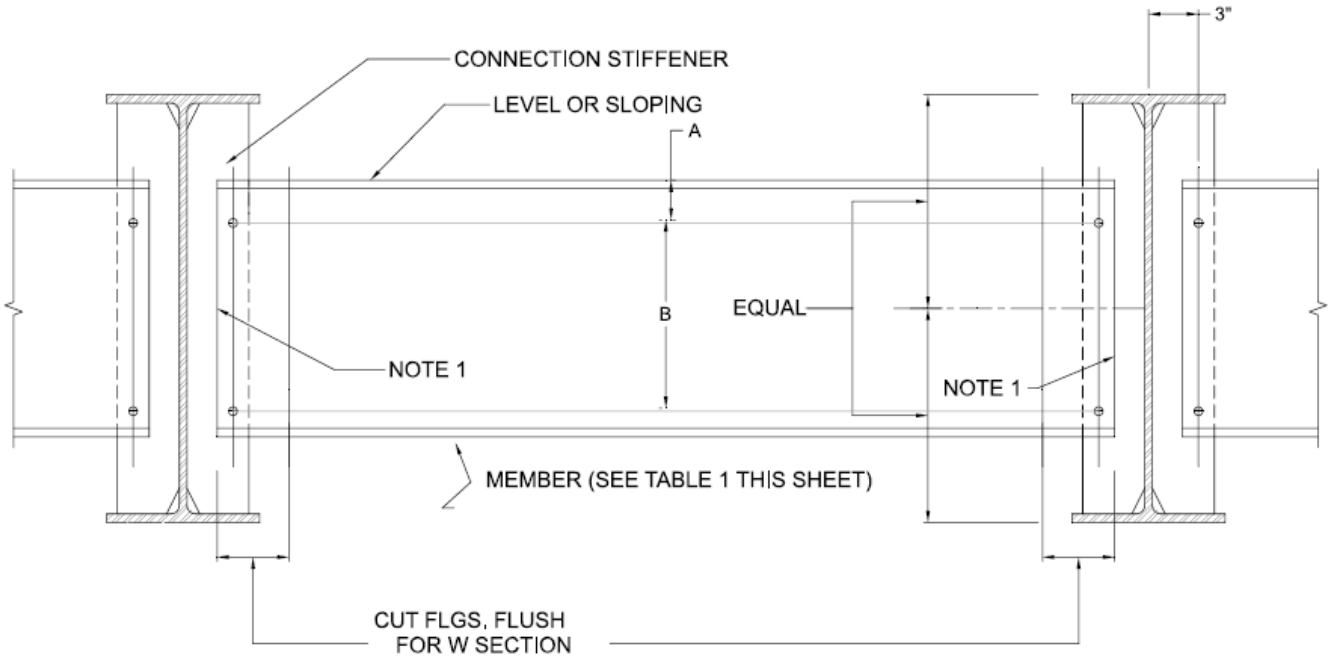
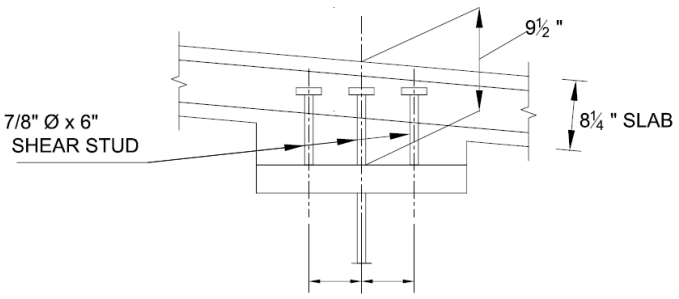
Design Example

- Typical diaphragm details:

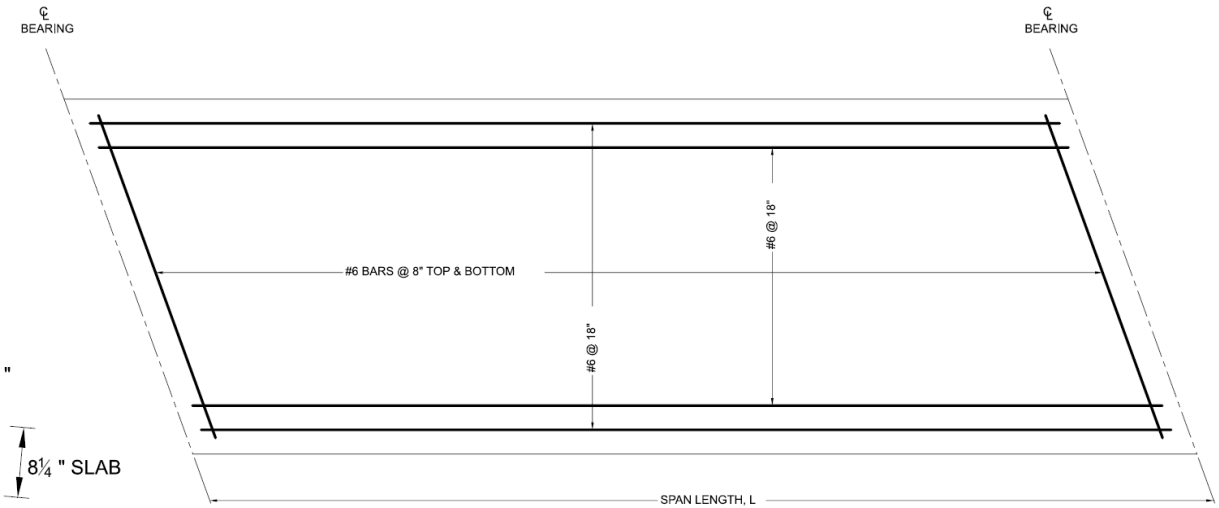


Design Example

- Typical section details:



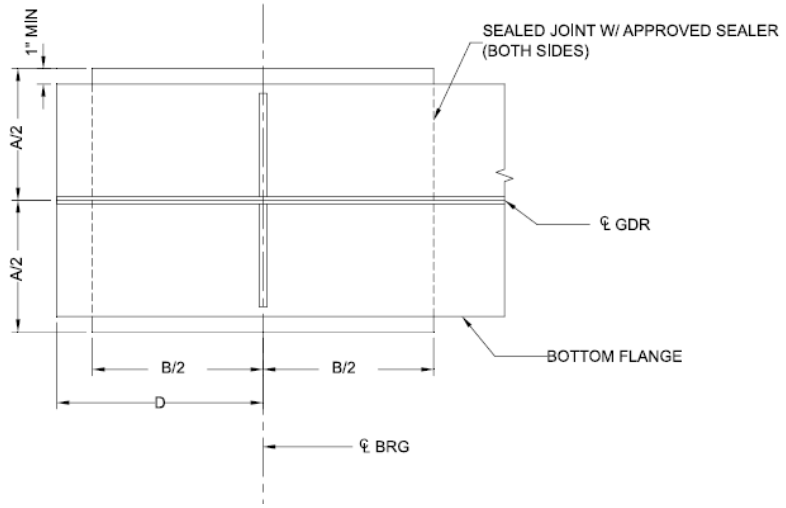
DETAIL A

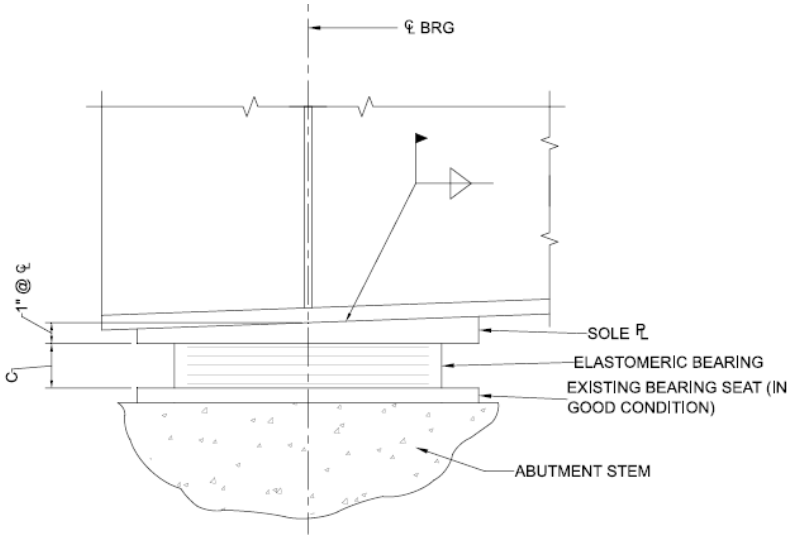


REINFORCING PLAN
(N.T.S.)

Design Example

- 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"

The New Steel

The Bridge Technology Center

West Virginia University

University of Wyoming — New Thinking

Marshall University

SHORT SPAN STEEL BRIDGE ALLIANCE™

NCSPA

- 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.

Questions?

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COUNTY ENGINEERS ASSOCIATION OF OHIO

"ALL TRAVEL STARTS AND ENDS ON A LOCAL ROAD"