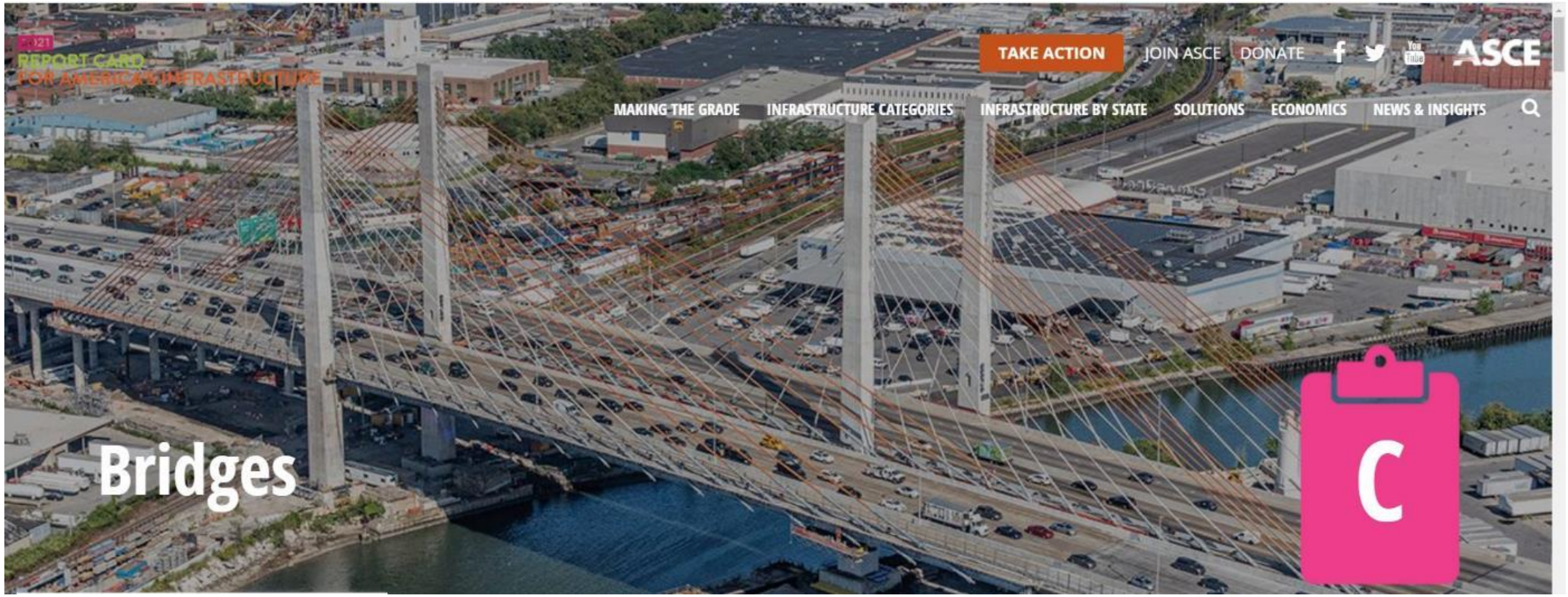
Short Span Steel Bridge Overview, Design Resources

Barron County Workshop & Bridge Tour
September 6, 2023

Michael Barker, PE
University of Wyoming
Short Span Steel Bridge Alliance

Bridge Industry Statistics – State of our Bridges



According to the American Society of Civil Engineers, a recent estimate for the nation's backlog of bridge repair needs is $125 billion through 2025.

It's a Great Time to Be in the Bridge Industry!

Bipartisan Infrastructure Law

+

= $39.5 Billion

$27 billion over 5 years to repair or replace as many as 15,000 bridges

Minimum 15% must be used to build "off-system" bridges

Additional $12.5 Billion for New Competitive Bridge Investment Program

Short Span Steel Bridge Alliance – Who We Are

A group of ***bridge*** *and* ***buried soil structure*** *industry leaders who have joined together to provide* ***educational information*** *on the design and construction of short span steel bridges in installations up to* ***140 feet in length****.*

Rolled Beam & Plate Girder

Buried Bridges

Truss

Press Brake Tub

SSSBA – Our Members

Producers

Fasteners

Coaters

Service Centers

Fabricators

SHORT SPAN STEEL
BRIDGE ALLIANCE™

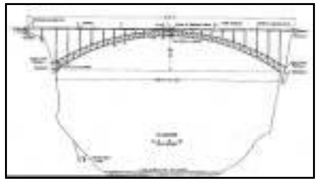
American Galvanizers Association

NCSPA

American Iron and Steel Institute

NSBA

Trade Organizations



Design Firms

Contractors

NATIONAL ASSOCIATION NACE COUNTY ENGINEERS

Bridge Owners

Universities

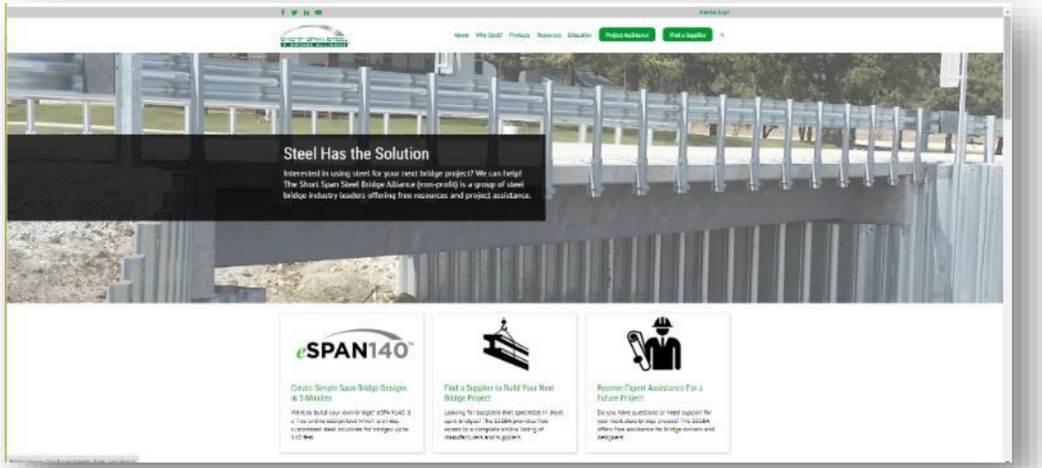
SSSBA – What We Do

- Education (webinars, workshops, forums, conferences)
- Technical Resources (standards, guidelines, best practices)
- Case Studies (economics: steel is cost-effective)
- Simple Design Tools (eSPAN140)
- Answer Questions (Bridge Technology Center)
- Prefabricated Bridge Manufacturers (industry contacts)
- Innovative & ABC Design

eSPAN140™

SSSBA Website: www.ShortSpanSteelBridges.org

- eSPAN140 Web-based Design Tool
- Bridge Technology Center
- Technical Design Resources
- Catalog of Short Span Steel Solutions
- Project Case Studies
- Video Library
- News Updates & Social Media (Twitter / LinkedIn / Facebook)
- Email Newsletter (sign-up to receive it)
- Calendar of Industry Events



www.ShortSpanSteelBridges.org

Common Simple Span Steel Bridge Types

Corrugated Steel Pipe
(Buried Steel Bridge)

Corrugated Steel Plate
(Buried Steel Bridge)

Rolled Beam Shape

Plate Girder

Truss

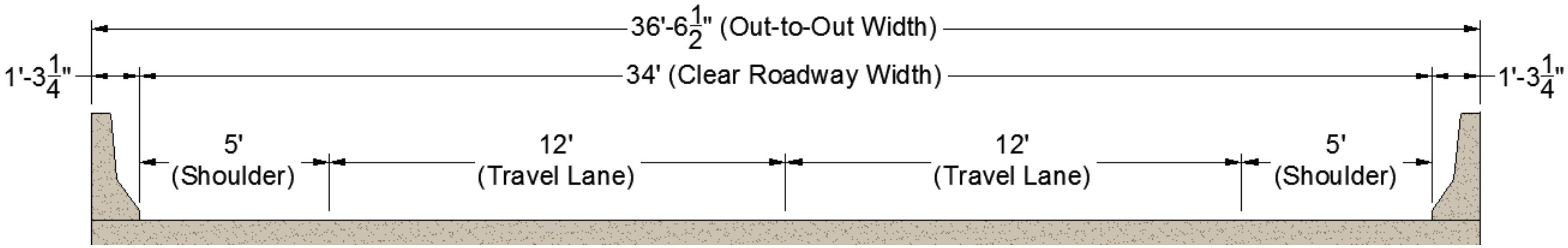
Press-Brake Tub Girder

Traditional Fabricated Steel Bridges

Design Superstructure for Two-Lane, 80 ft Simple Span Bridge

Bridge Need and Basic Information

- Decided by Owner/Engineer:
  - 80 ft Simple Span – Steel Girders
  - Two 12 ft Travel Lanes, ADT = 5600 one direction
  - No Clearance Issues / Can Close for Re-Decking
  - Concrete Riding Surface
  - 34 ft Roadway Width
  - Jersey Barriers (1 ft – 3 ¼ in wide)



Need an Initial Design for the Bridge SuperStructure

eSPAN140 - Standard Designs for Short Span Steel Bridges - www.ShortSpanSteelBridges.org

Goal:

- Economically competitive (repetitive details and member sizes)
- Expedite the design process
- Homogeneous plate girders
- Lightest weight rolled beams
- Limited depth rolled beams

AASHTO LRFD Bridge Design:

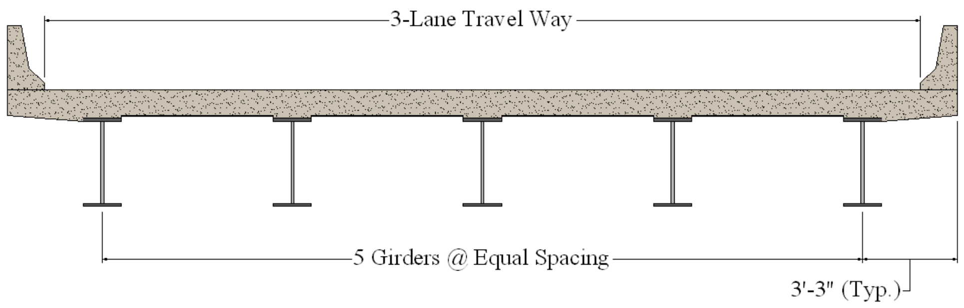
- Strength I,
- Service II,
- Fatigue,
- Constructability,
- L/800 Deflection
- HL-93 Vehicular Live Loading

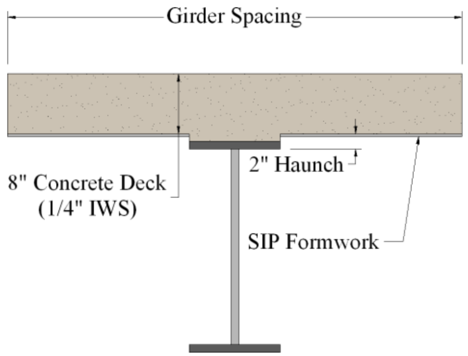
eSPAN140 - Standard Designs for Short Span Steel Bridges - www.ShortSpanSteelBridges.org

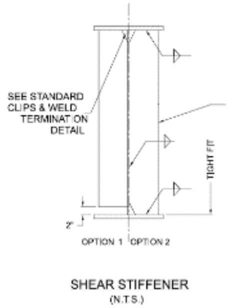
Span lengths 20 ft to 140 ft (in 5 ft increments)

Four girder spacing: 6’-0”, 7’-6”, 9’-0” and 10’-6”,

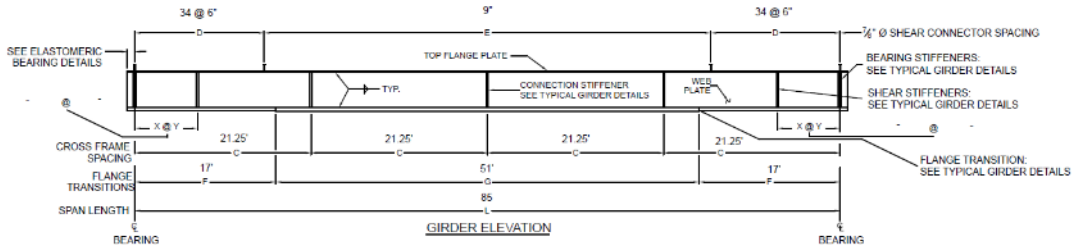
For each of these increments: Steel girders, Shear stud & stiffener layouts, Welding and fabrication details, Elastomeric bearings, and Concrete deck design

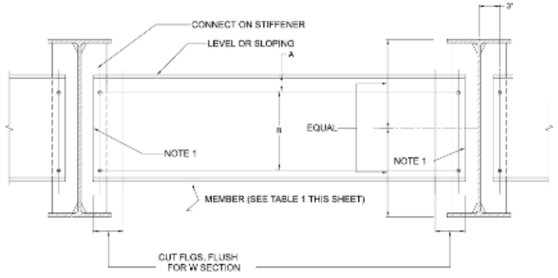






COMPOSITE PLATE GIRDER WITH PARTIALLY STIFFENED WEB - 4 GIRDERS AT 8' 10" GIRDER SPACING, HOMOGENEOUS



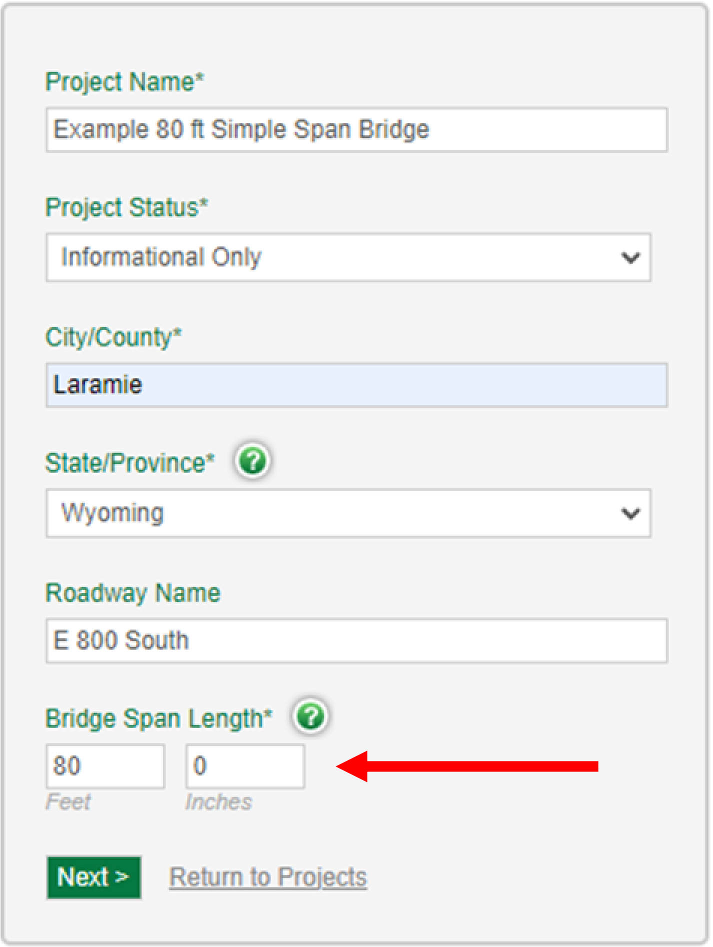


eSPAN140 Preliminary Design

Solution Type*	Bridge Span Length								Skew Angle	Overhang Width
	0'	20'	40'	60'	80'	100'	120'	140'		
Rolled Beam (40' to 100')**									+/- 20 degrees	3'3" or less
Homogeneous Plate Girder (60' to 140')**									+/- 20 degrees	3'3" or less
Press Brake Tub Girders (0' to 80')									+/- 20 degrees	3'3" or less
Buried Bridges (all)***									+/- 35 degrees****	N/A

* For bridges outside of this range, standard designs will not appear in your solutions book.
** Standard designs for rolled beam and plate girder solutions are rounded in five (5) foot increments.
*** Depending on project requirements this solution will require multiple spans.
**** Can be greater if site geometry allows.

eSPAN140 Preliminary Design


Project Name*

Example 80 ft Simple Span Bridge

Project Status*

Informational Only

City/County*

Laramie

State/Province*

Wyoming

Roadway Name

E 800 South

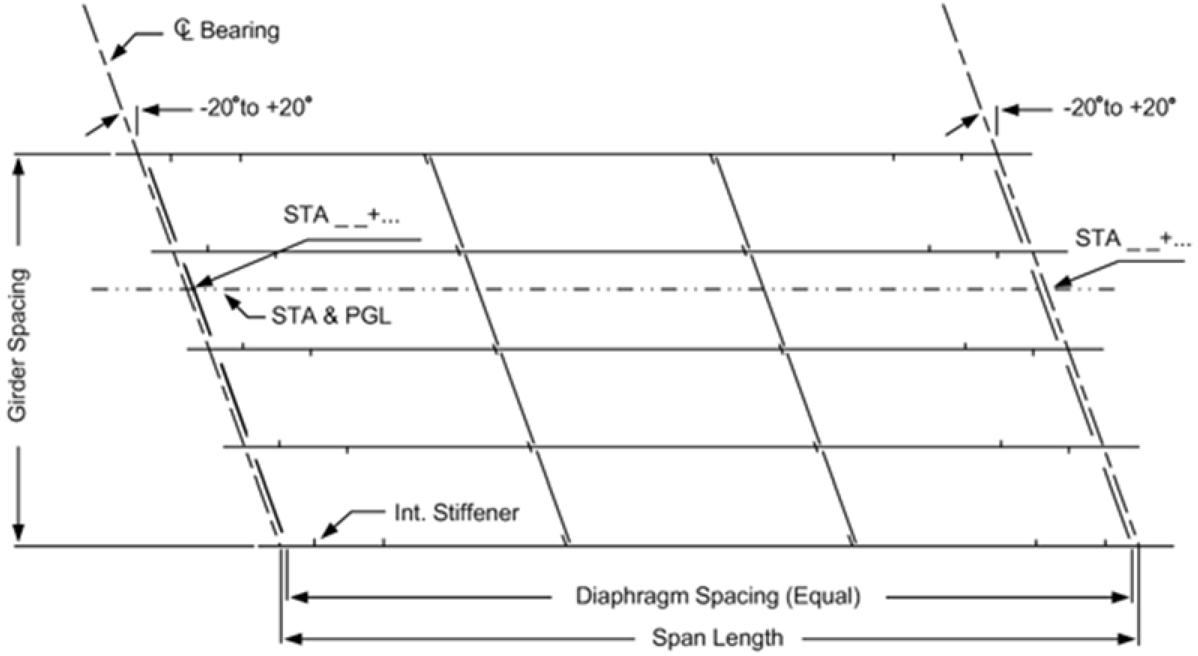
Bridge Span Length*

80 Feet

0 Inches

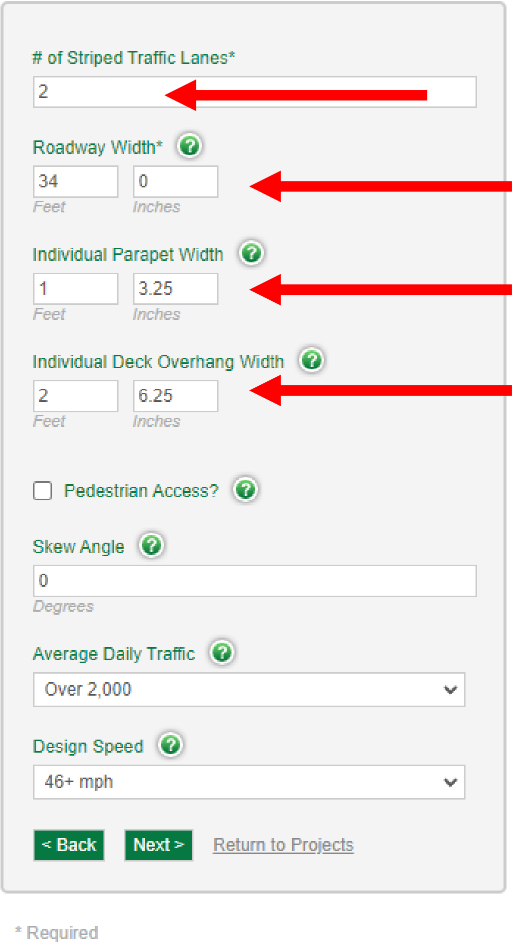
Next >

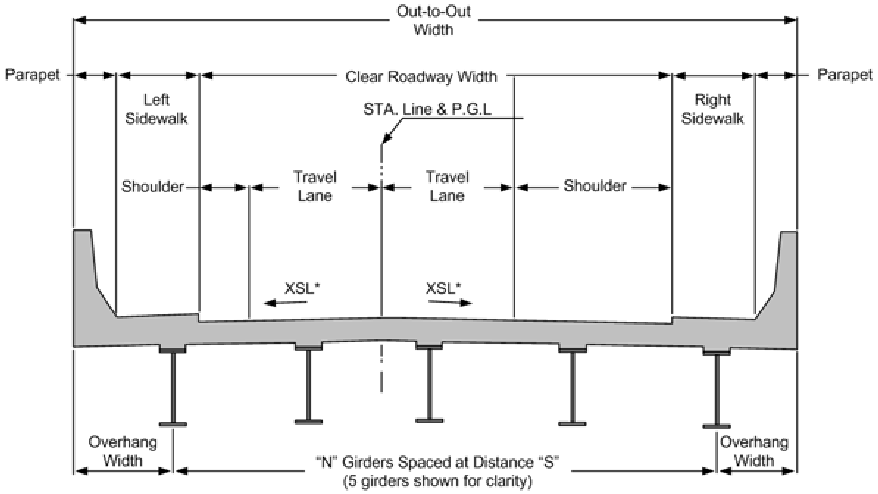
Return to Projects



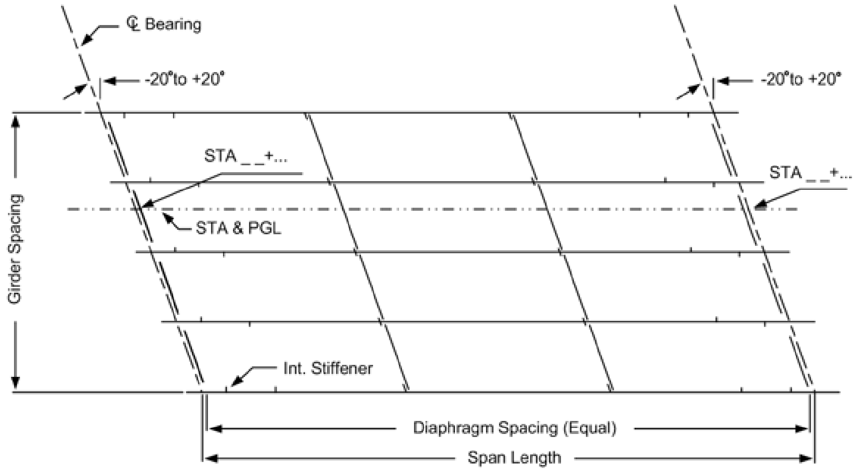
Skew Angle (Overhead View)

eSPAN140 Preliminary Design





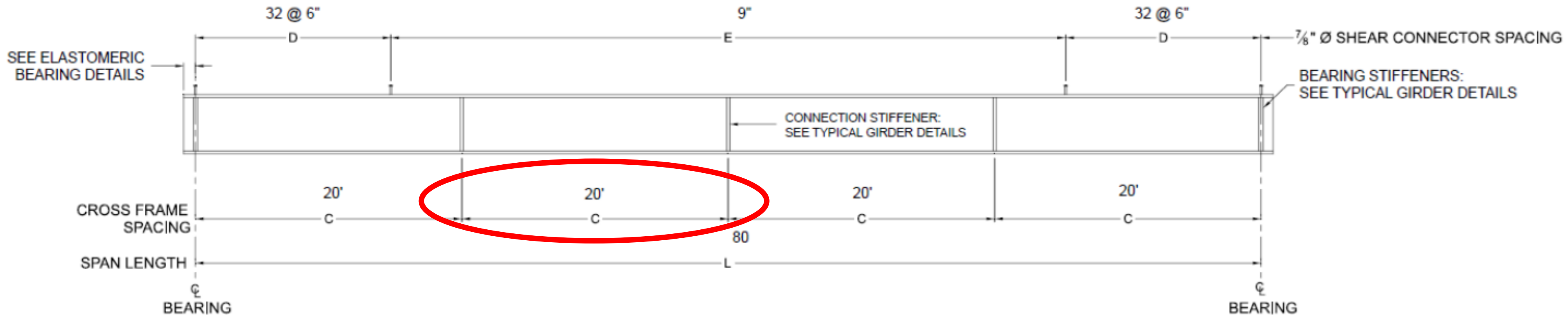
Cross-section of Bridge



Rolled Beam Recommendation

COMPOSITE ROLLED BEAM WITH PARTIALLY STIFFENED WEB - 4 GIRDERS AT 10' 6" GIRDER SPACING, LIGHTEST WEIGHT

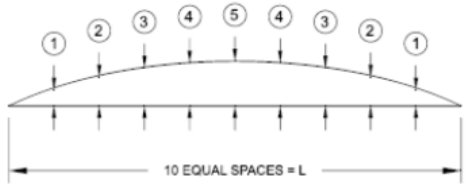
The selected rolled beam section is based on the widest (10'-6") girder spacing used in the development of the standards. The steel industry generally recommends the use of the widest girder spacing possible to reduce the potential number of girder lines for optimum economy.



BEAM ELEVATION

SPAN (L) - ft	ROLLED BEAM	DIAPHRAGM SPACING (C) - ft	SHEAR CONNECTOR MAX. SPACING		WEIGHT
			D	E	
80	W36x210	20'	32 @ 6"	9"	16,800 lbs

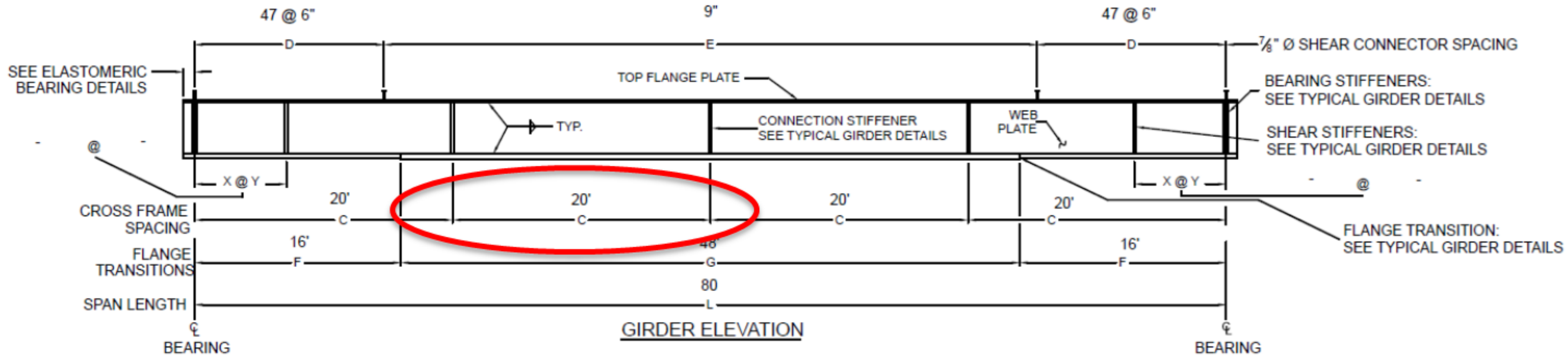
STEEL D.L. CAMBER - in					TOTAL D.L. CAMBER - in				
1	2	3	4	5	1	2	3	4	5
0.178"	0.337"	0.461"	0.540"	0.567"	1.255"	2.375"	3.250"	3.807"	3.997"



D.L. CAMBER

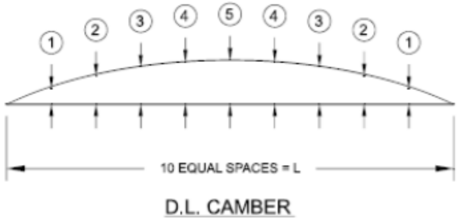
Homogeneous Plate Girder Recommendation

COMPOSITE PLATE GIRDER WITH PARTIALLY STIFFENED WEB - 4 GIRDERS AT 10' 6" GIRDER SPACING, HOMOGENEOUS

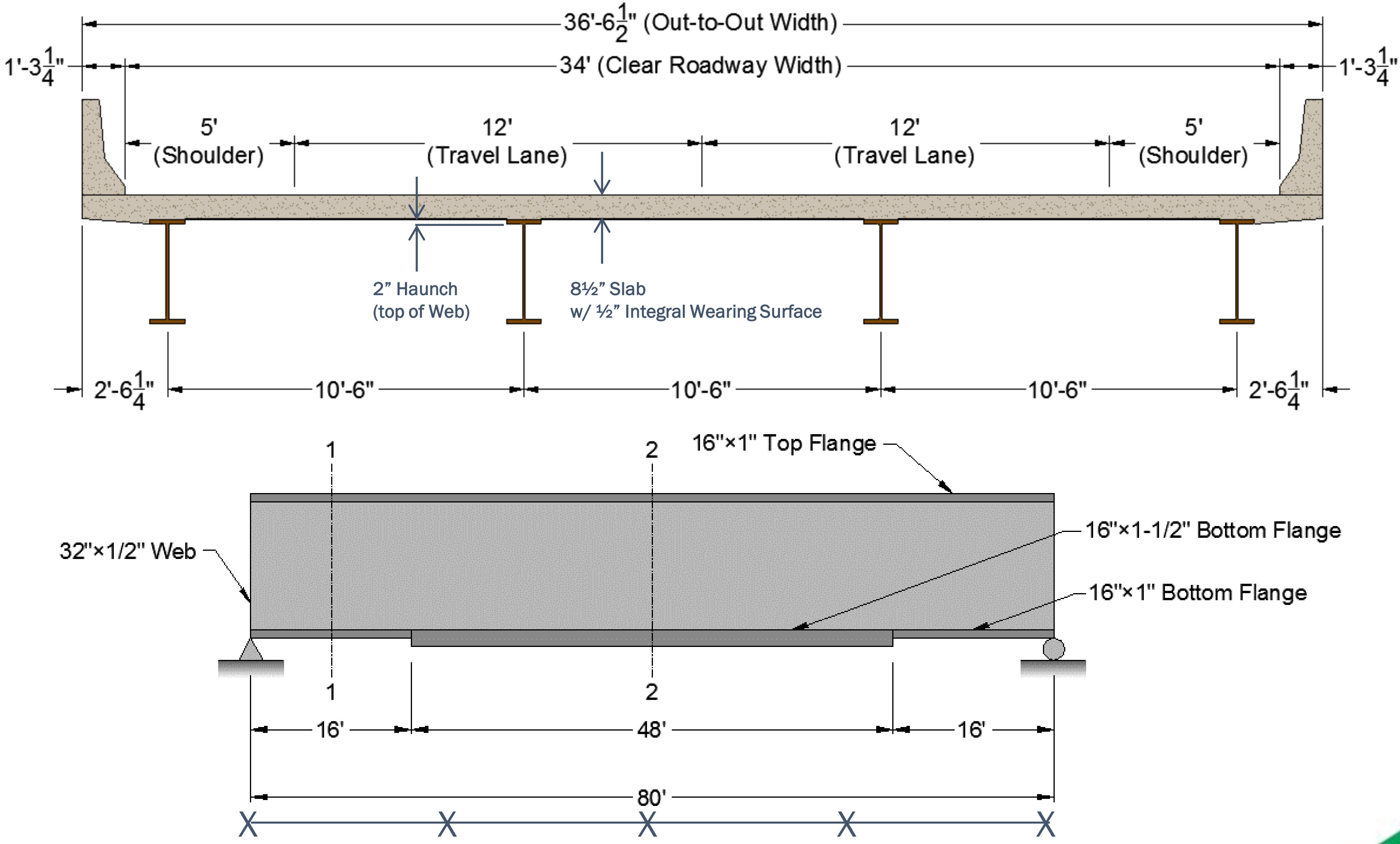


SPAN (L) - ft	PLATE GIRDER SIZE						DIAPHRAGM SPACING (C) - ft	SHEAR STIFFENERS		SHEAR CONNECTOR MAX. SPACING		INDIVIDUAL GIRDER WEIGHT
	TOP FLANGE - in	BOTTOM FLANGE (F)		BOTTOM FLANGE (G)		WEB PLATE- in						
		PLATE - in	LENGTH - Ft	PLATE - in	LENGTH - Ft			X (NO. REQ'd)	Y - ft. (SPACING)	D	E	
80	16 x 1"	16 x 1"	16'	16 x 1 1/2"	48'	32 x 1/2"	20'	-	-	47 @ 6"	9"	14,373 lbs

STEEL D.L. CAMBER - in					TOTAL D.L. CAMBER - in				
1	2	3	4	5	1	2	3	4	5
0.178"	0.334"	0.454"	0.530"	0.557"	1.397"	2.618"	3.554"	4.149"	4.355"



Design for Homogeneous Plate Girder Bridge



Lateral Bracing at 20 ft

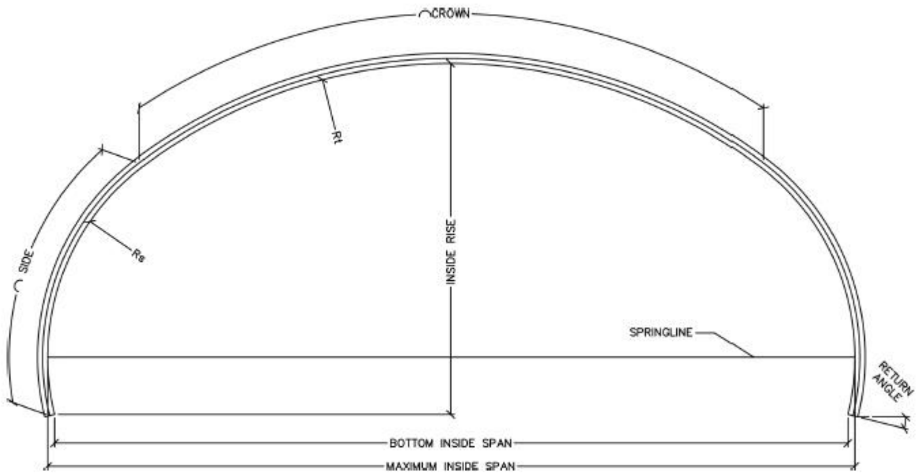
SSSBA Manufacturer Solutions

High Quality Beautiful Bridges
Economical
ABC

www.ShortSpanSteelBridges.org

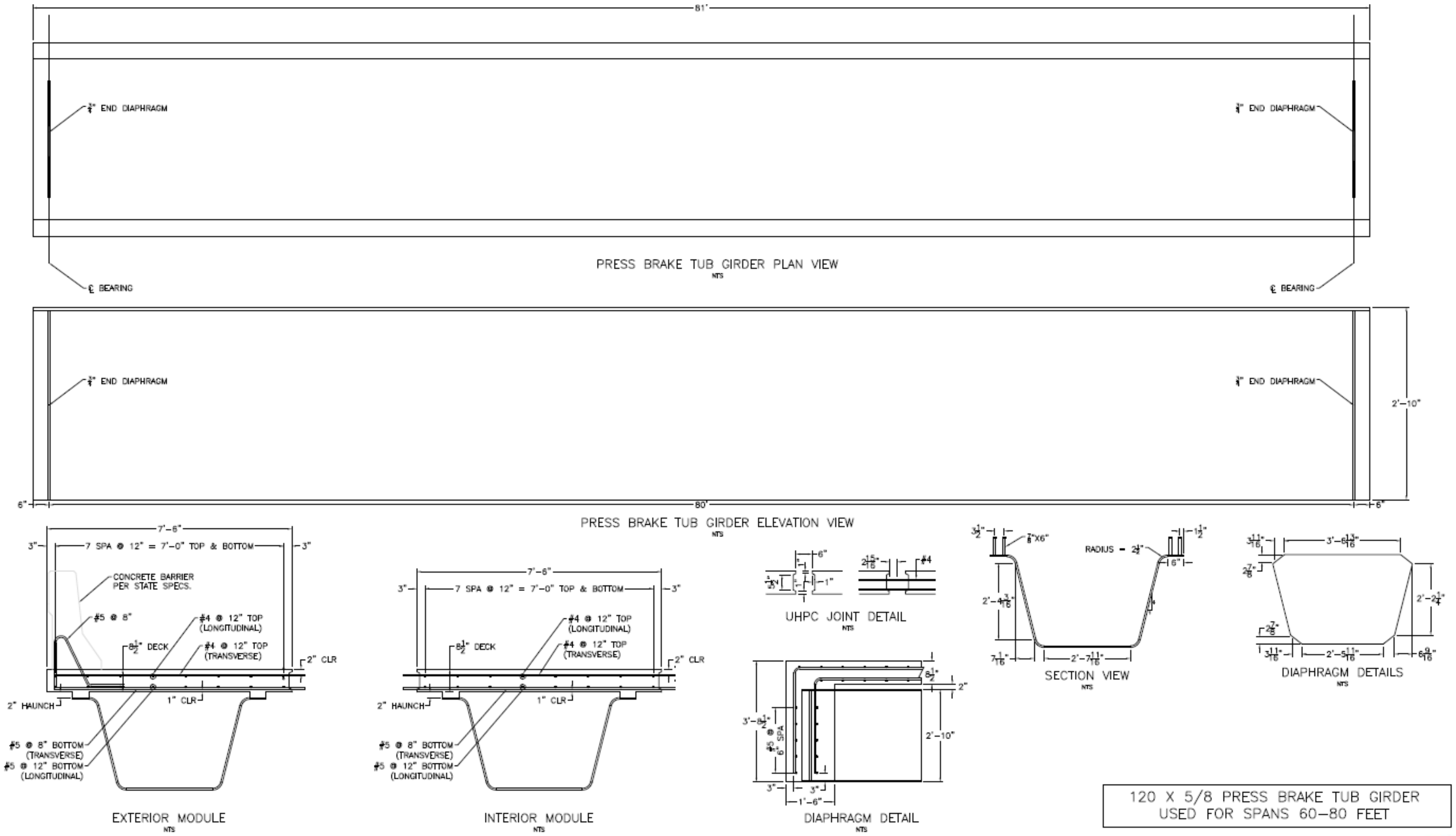
Buried Steel Bridge Recommendation

Multi-Radius Arch 15x5.5



SPAN - ft - in	RISE - ft - in	BOTTOM SPAN - ft - in	WATERWAY AREA - ft²	RADIUS - in		RETURN ANGLE
				Rt	Rc	
80' 5"	24' 0"	80' 0"	1545.0'	745"	174"	8.1

Press Brake Tub Girder Recommendation



Bridge Economy & Life Cycle Costs

Barron County Workshop & Bridge Tour
September 6, 2023

Michael Barker, PE
University of Wyoming
Short Span Steel Bridge Alliance

Initial Costs: Steel & Concrete

Preconception that Concrete is Less Expensive than Steel for Typical Bridges

Many Times Steel is Not Even Considered

Owners Paying More Than They Could for Bridges

Unwarranted Lack of Competition Not Good

Missouri County Bridges – Where the SSSBA Began

Steel

<u>Audrain County, MO Bridge 411</u>
Built 2012
Steel 4 Girders
47.5 ft. Span
24 ft. Roadway Width
2 ft. Structural Depth
No Skew

Concrete

<u>Audrain County, MO Bridge 336</u>
Built 2012
Precast 6 Hollowcore Slab Girders
50.5 ft. Span
24 ft. Roadway Width
2 ft. Structural Depth
20^{o} Skew

County Crew Built Bridges

Side-by-Side Comparison Total Cost of Structure

Steel

Concrete

19.3% Total Bridge Cost Savings with Steel

Steel – Total Bridge Costs

Material	= $41,764
Labor	= $24,125
Equipment	= $21,521
Guard Rail	= $ 7,895
Rock	= $ 8,302
Engineering	= $ 8,246
TOTAL	= $111,853 ($97.48 / sq. ft.)

Concrete – Total Bridge Costs

Material	= $67,450
Labor	= $26,110
Equipment	= $24,966
Guard Rail	= $ 6,603
Rock	= $ 7,571
Engineering	= $21,335
TOTAL	= $154,035 ($120.83 / sq. ft.)

Superstructure Only Comparison

Steel		Concrete	
Superstucture Costs		Superstructure Costs	
Material		Material	
Girders	= $ 21,463	Slab Girders	= $ 50,765
Deck Panels	= $ 7,999	Deck Panels	= $ 0
Reinf Steel	= $ 3,135	Reinf Steel	= $ 724
Concrete	= $ 4,180	Concrete	= $ 965
Labor	= $ 5,522	Labor	= $ 4,884
Equipment*	= $ 500	Equipment*	= $ 4,000
SUPER TOTAL	= $ 42,799	SUPER TOTAL	= $ 61,338
SUPER TOTAL	= $37.54 / sq. ft.	SUPER TOTAL	= $50.61 / sq. ft.

**Added cost to use galvanized steel = $5,453.80 or $0.22 / lb. (includes est. 10% fabrication fee)*
*** Cost to use weathering steel is approximately $0.04 / lb. (already included in cost in example)*

*County Crane (30 Ton) used for Steel, Larger Rented Crane (100 Ton) Required for Concrete (Equivalent County Crane Cost is $1520, would result in Steel Cost of $38.88 / sq. ft.)

True Cost Comparison Steel vs Concrete

Steel: Superstructure $37.54 per sq. ft.

Concrete: Superstructure Cost $50.61 per sq. ft.

25.8% superstructure cost savings

<u>Same bridge conditions:</u>

- Structural Depth = 2 ft. (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

Case Study Bridges: Other Bridges in Audrain County

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**

Missouri DOT State Bridges

Both Bridges Cross US 63 in Boone County

Concrete P/S: 92 ft – 92 ft

Route H (Columbia Airport)

Built 2011

Steel Plate Girder: 98 ft – 98 ft

Discovery Parkway (Columbia)

Built 2007

Missouri DOT State Bridges

Both Bridges Cross US 63 in Boone County

Concrete P/S: 92 ft – 92 ft

Route H (Columbia Airport)

Built 2011

Letting Date 5/27/2011					
1800	206-10.00	Class 1 Excavation	85	CUYD	$1,700.00
1810	702-10.12	Structural Steel Piles (12 in.)	737	LF	$33,533.50
1820	702-60.00	Pre-Bore for Piling	240	LF	$9,600.00
1830	702-70.00	Pile Point Reinforcement	22	EA	$2,420.00
1840	703-20.03	Class B Concrete (Substructure)	76.2		
1850	703-42.13	Slab on Concrete I-Girder			
1860	703-42.15				
1870	705				
1880	706-				
~~1890~~	~~707~~				
1900	712-				
1910	715-1				
1920	716-1				
1930	716-1			EA	$2,480.00
1940	725-10	Spacers	10	EA	$20,000.00
			Total Bridge Cost =		$440,632.50
			Cost/ft² =		$77.71

Steel Plate Girder: 98 ft – 98 ft

Discovery Parkway (Columbia)

Built 2007

Letting Date 9/28/2007					
1560	206100	Class 1 Excavation			
1580	7021012	Structural			
~~1570~~					
				LB	$15,029.00
				~~L.S.~~	~~$7,000.00~~
			12	EA	$2,400.00
	7151001	Vertical Drain at End Bents	2	EA	$4,000.00
1720	7162000	Laminated Neoprene Bearing Pad	9	EA	$10,800.00
1710	7161003	Laminated Neoprene Bearing Pad (Tapered)	18	EA	$6,750.00
1730	7251000	Corrugated Metal Pipe Pile Spacers	20	EA	$5,000.00
1670	7125365A	Intermediate Field Coat (System G)	22100	SQFT	$30,940.00
1680	7125370A	Finish Field Coat (System G)	2800	SQFT	$3,220.00
~~1690~~	~~7129911~~	~~Misc. Fab. Struc. Low Alloy Steel (Aesthethics~~	~~24330~~	~~LB~~	~~$54,742.50~~
			Total Bridge Cost =		$1,057,538.80
			Cost/ft² =		$64.04
			Cost/ft² with ENR CCI Adjustment of 1.139 =		$72.94

Using ENR CCI Index Increase of 2.7%/yr For 2017

Concrete = $ 91.18/ft²

Steel = $ 85.58/ft²

Summary on Initial Costs

SSSBA Conducted Case Studies:

- County & State Bridges
- Bids & Actual Costs
- Case Studies of County Bridges
- **Others Not Shown Here**

NSBA Cost Study

Superstructure	Steel						Concrete				
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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											
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- 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 FT²	$74.68	$83.91	$80.01	$102.42	$84.68	$86.09	$91.54	$107.63	$95.48	$91.23	$96.32

Case Study Bridges: Audrain County, MO

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Concrete: Superstructure Cost $50.61 per sq. ft.

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- Same Guard Rail System
- Same Work Crew

State Bridge (Designed by eSPAN140)

Kansas Department of Transportation

- Shawnee County
- 112 feet (5 plate girder bridge)
- Competitive bid process (steel vs. concrete)
- DOT used eSPAN140 for preliminary design
- Constructed in summer 2014

1 Steel Bridge Bid

3 Concrete Bridge Bids

Steel = $ 1.240 mil

Concrete = $ 1.243 – $ 1.425 mil

County Bridge (Designed by eSPAN140)

- **Boone County, Missouri (Local)**
  - High Point Lane Bridge
  - 102 feet (2 lane rural road plate girder bridge)
  - 44" weathering steel plate girders (4 lines)
  - Constructed in summer 2013

Two MoDOT Bridges Crossing US 63 in Boone County

Concrete P/S: 92 ft – 92 ft

Route H (Columbia Airport)

Letting Date 5/27/2011					
1800	206-10.00	Class 1 Excavation	85	CUYD	$1,700.00
1810	702-10.12	Structural Steel Piles (12 in.)	737	LF	$33,533.50
1820	702-60.00	Pre-Bore for Piling	240	LF	$9,600.00
1830	702-70.00	Pile Point Reinforcement	22	EA	$2,420.00
1940	725-10.00	Corrugated Metal Pipe Pile Spacers	10	EA	$20,000.00

Total Bridge Cost = $440,632.50

Cost/ft² = $77.71

Steel Plate Girder: 98 ft – 98 ft

Discovery Parkway (Columbia)

Letting Date 9/28/2007					
1560	206100	Class 1 Excavation	130	CUYD	$4,420.00
1580	7021012	Structural Steel Piles (12 in.)	1850	LF	$64,750.00
~~1570~~	~~6071066~~	~~Pedestrian Fence~~	~~470~~	~~LF~~	~~$33,840.00~~
1590	7027000	Pile Point Reinforcement	60	EA	$5,700.00
1730	7251000	Corrugated Metal Pipe Pile Spacers	20	EA	$5,000.00
1670	7125365A	Intermediate Field Coat (System G)	22100	SQFT	$30,940.00
1680	7125370A	Finish Field Coat (System G)	2800	SQFT	$3,220.00
~~1690~~	~~7129911~~	~~Misc. Fab. Struc. Low Alloy Steel (Aesthethics~~	~~24330~~	~~LB~~	~~$54,742.50~~

Total Bridge Cost = $1,057,538.80

Cost/ft² = $64.04

Cost/ft² with ENR CCI Adjustment of 1.139 = $72.94

Using ENR CCI Index Increase of 2.7%/yr

For 2017 Concrete = $ 91.18/ft²

Steel = $ 85.58/ft²

Steel Bridges Compete and Win!

What About Life Cycle Costs?

As owners replace their bridge infrastructure, the question of Life Service and Life Cycle Costs routinely comes up between concrete and steel bridge options

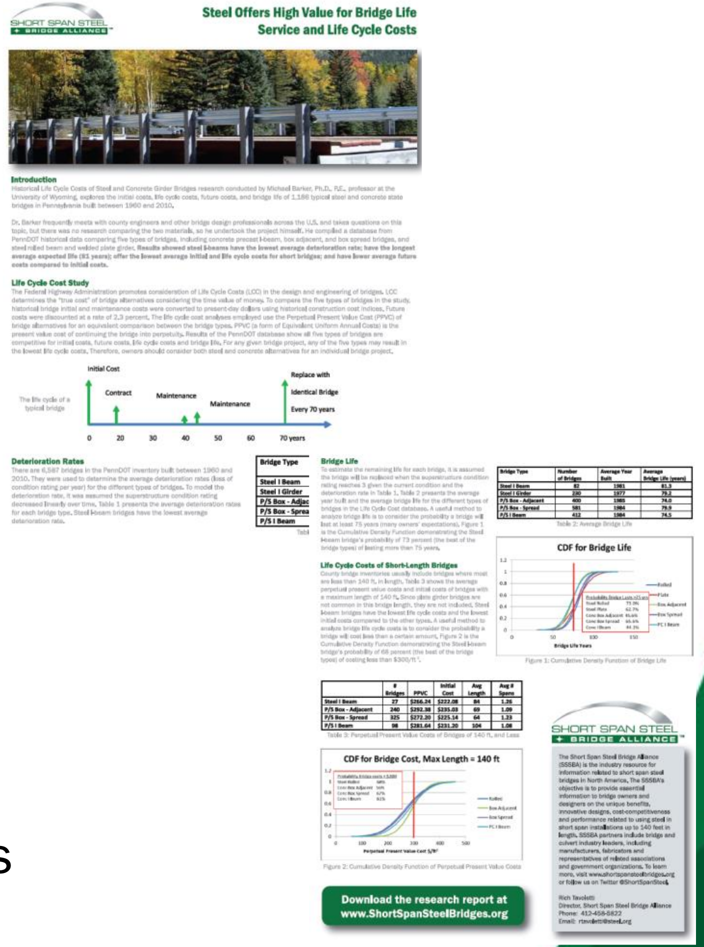
The bridge industry ~~does~~ did not have a good answer:

Both steel and concrete bridge advocates claim an advantage

Anecdotal information is not convincing

Historical Life Cycle Costs of Steel & Concrete Girder Bridges

Examine Historical Life Service (Performance and Maintenance) and Agency Life Cycle Costs (True Agency Costs for a Bridge) of Steel and Concrete Bridges in Pennsylvania



Report on ShortSpanSteelBridges.org

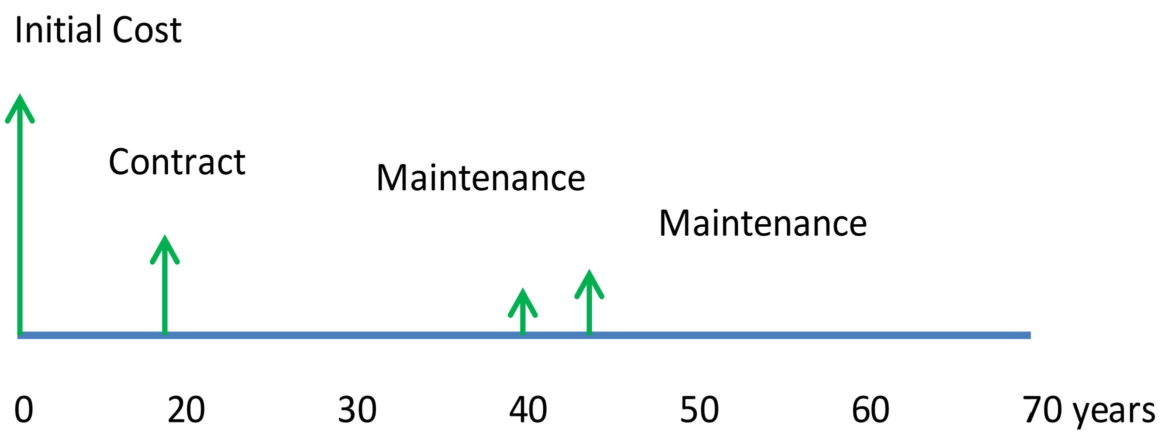
Additional Report on Galvanized Bridges

Thank You to PennDOT professionals for their participation
Support from AISI, NSBA and AGA

Life Cycle Cost Data Collection

Start with a Comprehensive Inventory of Bridges

Initial Costs & Date Built
Maintenance Costs and Date Performed
End of Service Date – End of Life Model



PennDOT Database Development

Criteria to Develop LCC Bridge Database

Modern typical bridge structures

Precast I-Beam, Box Adjacent, and Box Spread bridges

Steel Rolled Shape and Welded Plate Girder bridges

Bridges built between 1960 and 2010

Bridges with complete and accurate department maintenance records

Consider any maintenance cost that is equal to or greater than $0.25/ft^2

Bridges with known initial costs

Bridges with complete and accurate external contractor maintenance and rehabilitation

Initial cost limitation to bridges with initial cost less than $500/ft^2 and greater than $100/ft^2

Note: Total Recorded Initial and Maintenance Costs Used

PennDOT Database Development

All Bridges in PennDOT Inventory = 25,403
Number of Type Bridges in Inventory = 8,466
Number of Types Built 1960-2010 = 6,587

Bridges that Meet All Criteria

Bridge Type	Number of Bridges that Meet All criteria	Percentage of 1960 – 2010 database
Steel I Beam	82	14.9%
Steel I Girder	230	22.6%
P/S Box - Adjacent	400	27.8%
P/S Box - Spread	581	26.5%
P/S I Beam	412	29.8%
Total	1705	25.9%

PennDOT Database Bridge Life Model

Bridge Life Model uses Average Deterioration Rates of Total PennDOT Inventory

Assume Bridge Replacement at Condition Rating = 3
Super Structure Condition Rating Used

$$Deterioration\ Rate = \frac{(2014\ Condition\ Rating) - 9}{2014 - (Year\ Built)}$$

$$Remaining\ Life = \frac{3 - (2014\ Condition\ Rating)}{(Average\ Deterioration\ Rate)}$$

$$Bridge\ Life = 2014 - (Year\ Built) + Remaining\ Life$$

Bridge Type	Number of Bridges 1960 - 2010	Deterioration Rate (Condition Rating Loss/Year)
Steel I Beam	**550**	**-0.07114**
Steel I Girder	**1017**	**-0.08144**
P/S Box - Adjacent	**1440**	**-0.08125**
P/S Box - Spread	**2196**	**-0.07988**
P/S I Beam	**1384**	**-0.08383**

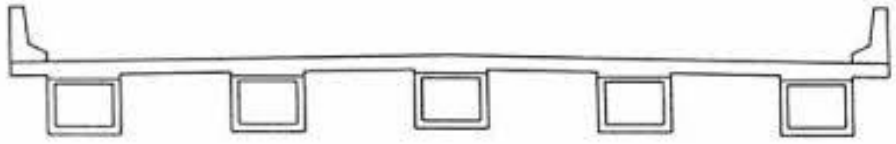
↑ Steel Rolled
Precast Box Spread

All are "similar" with None "Way Out" of Balance

Agency Life Cycle Costs – An Example

Precast Spread Box-Beam Bridge

BrKey:	30570
Bridge Type:	P/S, Box Beam (Spread)
County:	Shuylkill
Location:	0.75 mi. N of Exit 107(33)
Year Built:	1969
Spans:	3
Length:	176 ft
Deck Area:	7621 ft^2
Super Cond Rating:	5



Average Precast Box Beam – Spread bridge deterioration rate = -0.07988

$$Remaining\ Life = \frac{(3-5)}{-0.07988} = 25\ years$$

$$Bridge\ Life = 2014 + 25 - 1969 = 70\ years$$

Life Cycle Costs

Example Bridge Costs

Actual Costs / Years

Initial Cost:	Year = 1969	Cost = \$141475 (\$18.56/ft^2)	Work: Bridge Construction
External Contract:	Year = 1988	Cost = \$58401 (\$7.66/ft^2)	Work: Latex Overlay
Maintenance 1:	Year = 2009	Cost = \$1891 (\$0.25/ft^2)	Work: Repair Concrete Deck
Maintenance 2:	Year = 2013	Cost = \$2510 (\$0.33/ft^2)	Work: Repair Concrete Deck

Equivalent 2014 Costs / Years

ENR Construction Cost Indices

$$2014\ Dollars = \frac{CCI\ 2014}{CCI\ 19XX} 19XX\ Dollars$$

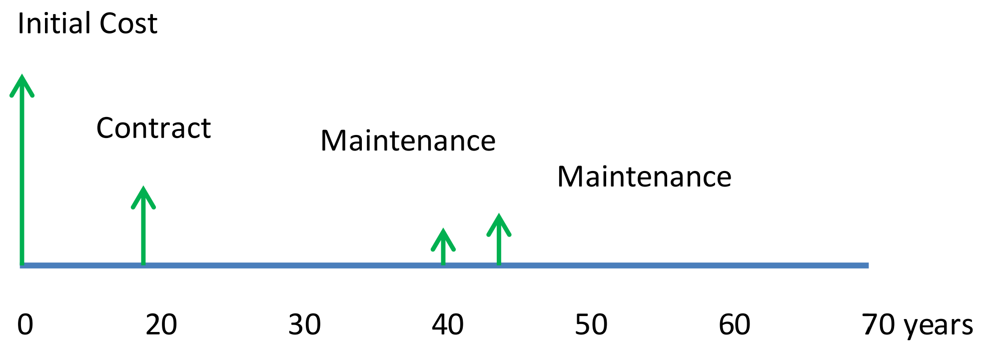
Transform the costs to constant 2014 dollars using Construction Cost

Initial Cost:	Year = 0	Cost = \$18.56/ft^2(9806/1269)	= \$143.45/ft^2
External Contract:	Year = 19	Cost = \$7.66/ft^2(9806/4519)	= \$ 16.63/ft^2
Maintenance 1:	Year = 40	Cost = \$0.25/ft^2(9806/8570)	= \$ 0.28/ft^2
Maintenance 2:	Year = 44	Cost = \$0.33/ft^2(9806/9547)	= \$ 0.34/ft^2

Life Cycle Costs

OMB Circular A-94 2011 30 yr Discount Rate = 2.3%

Example Bridge Life Cycle



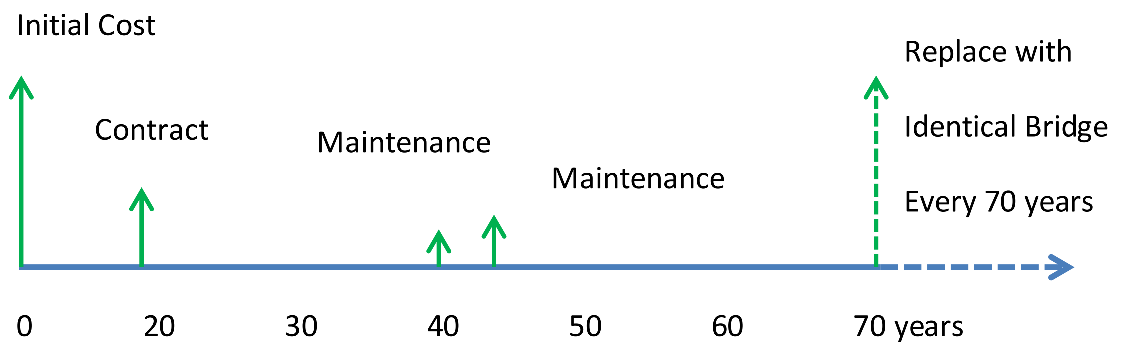
Present Value Cost for 1 Cycle

$$PVC = \$143.45 + \$16.63(1.023)^{-19} + \$0.28(1.023)^{-40} + \$0.34(1.023)^{-44} = \$154.49/ft^2$$

Life Cycle Costs

OMB Circular A-94 2011 30 yr Discount Rate = 2.3%

Example Bridge Life Cycle



Present Value Cost for 1 Cycle

$$PVC = \$143.45 + \$16.63(1.023)^{-19} + \$0.28(1.023)^{-40} + \$0.34(1.023)^{-44} = \$154.49/ft^2$$

Perpetual Present Value Cost = Capitalized Cost

$$PPVC = \$154.49\left[\frac{(1+0.023)^{70}}{(1+0.023)^{70}-1}\right] = 1.256(\$154.49) = \$193.97/ft^2$$

With Capitalized Costs, Can Compare Bridges Directly

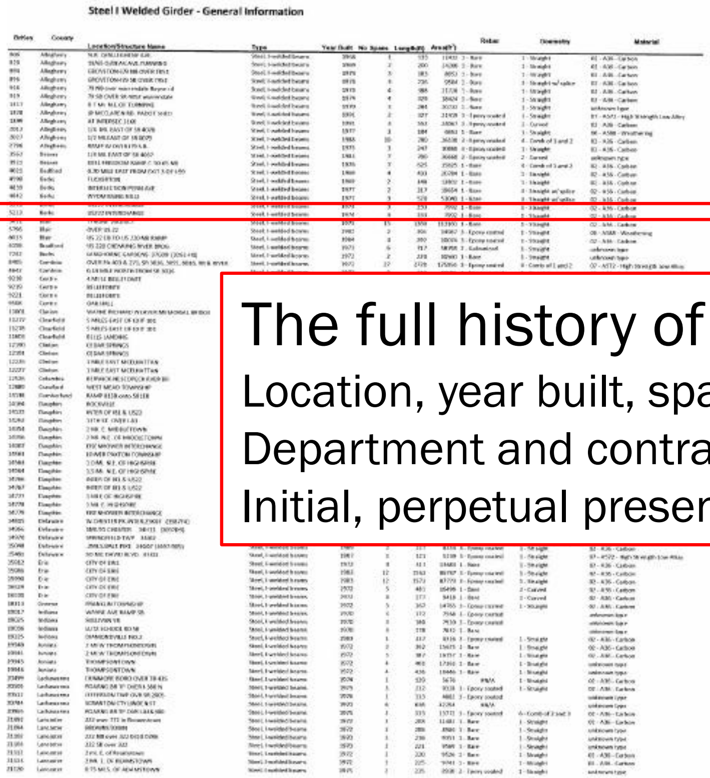
Life Cycle Cost Analyses

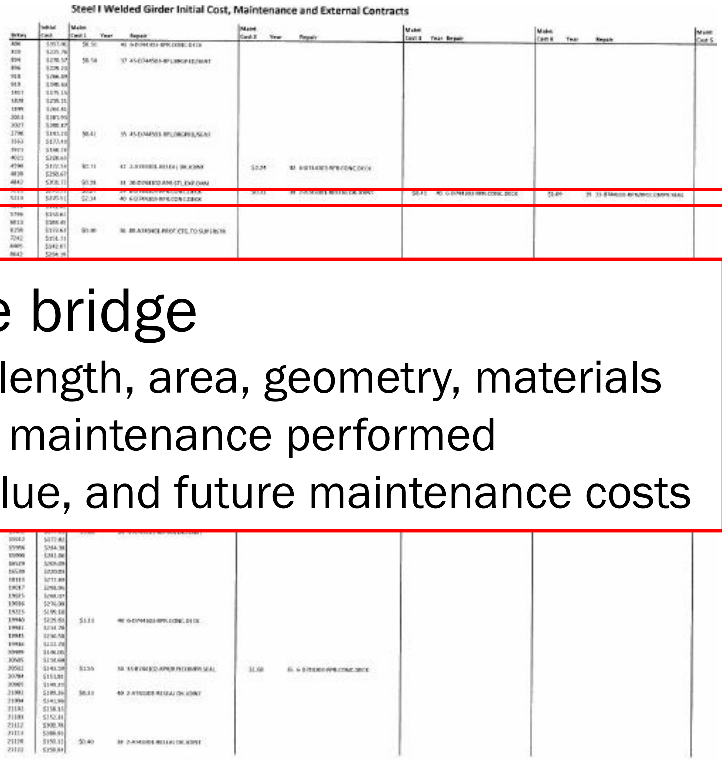
The Steel Plate Girder Bridge Data Base

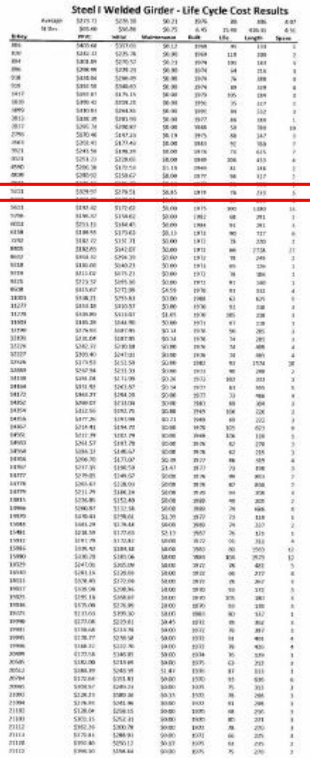
General Information

Maintenance & Contract Work

Initial & LCC


Steel I Welded Girder - General Information


Steel I Welded Girder Initial Cost, Maintenance and External Contracts


Steel I Welded Girder - Life Cycle Cost Results

The full history of the bridge

Location, year built, spans, length, area, geometry, materials

Department and contractor maintenance performed

Initial, perpetual present value, and future maintenance costs

LCC Report

Analysis and Variables Examined in Report

- Bridge Life
- PPVC/Capitalized Costs
  - Number of Spans
  - Bridge Length
  - PVC Future Costs
  - Department Maintenance
  - External Contracts

For Steel Bridges

- Curved vs. Straight
- Fracture-Critical
- Protection (Painted, Weathering, Galvanized)

For the entire report:
www.ShortSpanSteelBridges.org

Additional LCC report on Galvanizing:
www.ShortSpanSteelBridges.org

Bridge Life

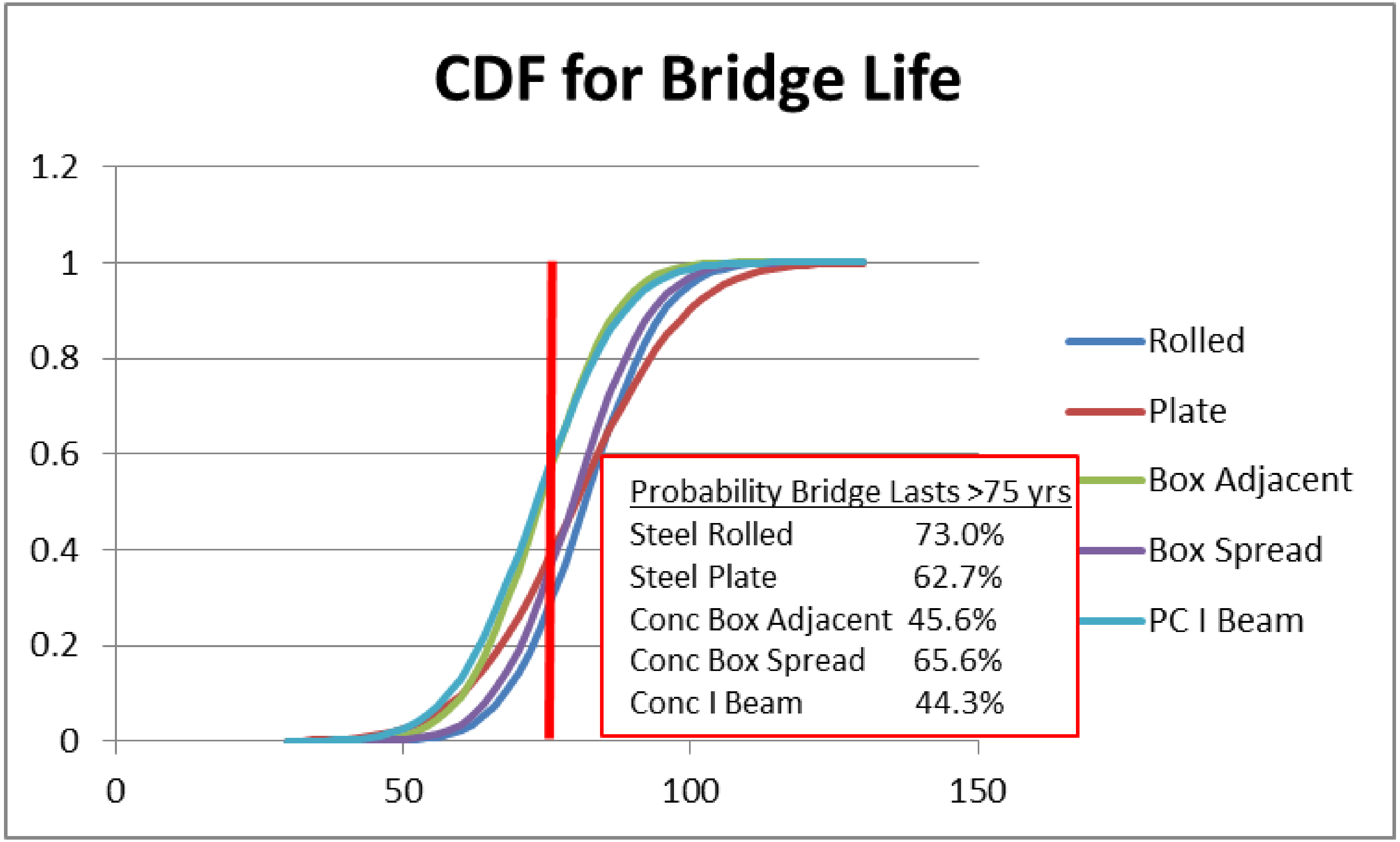
Bridge Type	Number of Bridges in Final LCC Database	Average Year Built	Average Bridge Life (years)
Steel I Beam	82	1981	81.3
Steel I Girder	230	1977	79.2
P/S Box - Adjacent	400	1985	74.0
P/S Box - Spread	581	1984	79.9
P/S I Beam	412	1984	74.5

↑

Steel Rolled
Precast Box - Spread

All are "similar" with None "Way Out" of Balance

Bridge Life


CDF for Bridge Life
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
Rolled
Plate
Box Adjacent
Box Spread
PC I Beam
Probability Bridge Lasts >75 yrs
Steel Rolled 73.0%
Steel Plate 62.7%
Conc Box Adjacent 45.6%
Conc Box Spread 65.6%
Conc I Beam 44.3%

Life Cycle Costs – All Bridges

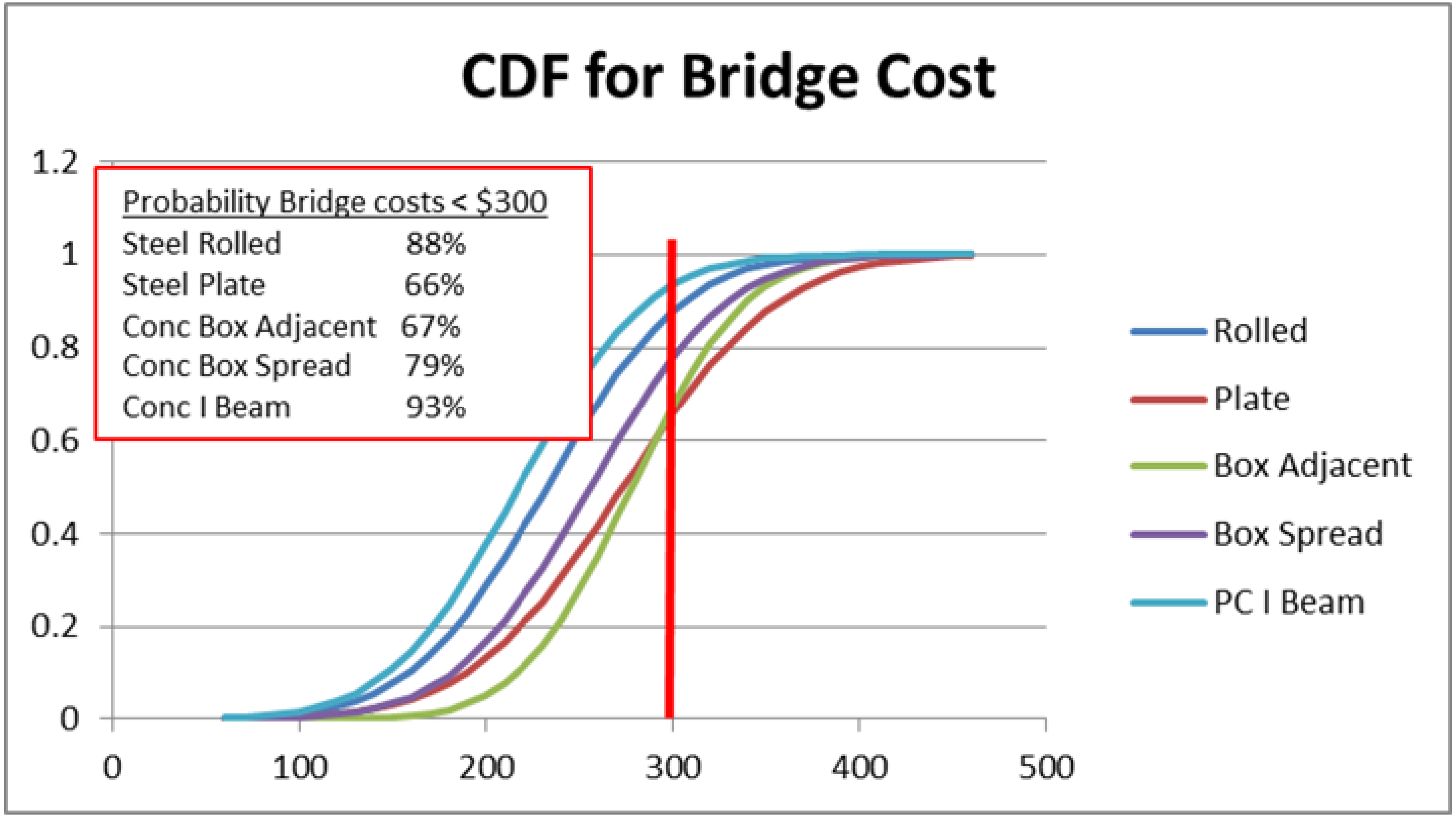
	# Bridges	PPVC	Initial Cost	Future Cost	Avg Length	Avg # Spans	Avg Year Built	Avg Life
Steel I Beam	54	$232.78	$194.78	$0.42	166	2.19	1980	82
Steel I Girder	144	$273.71	$226.10	$0.21	406	4.07	1976	80
P/S Box - Adjacent	282	$278.30	$223.74	$0.96	89	1.31	1987	74
P/S Box - Spread	397	$256.11	$210.65	$2.06	89	1.56	1986	79
P/S I Beam	309	$217.50	$174.10	$0.20	212	2.43	1985	73

↑

Precast I Beam
Steel Rolled

All are "similar" with None "Way Out" of Balance

Capitalized Costs – All Bridges



Life Cycle Costs– Length<140 ft

Short Length Bridges
Short Span Steel Bridge Alliance

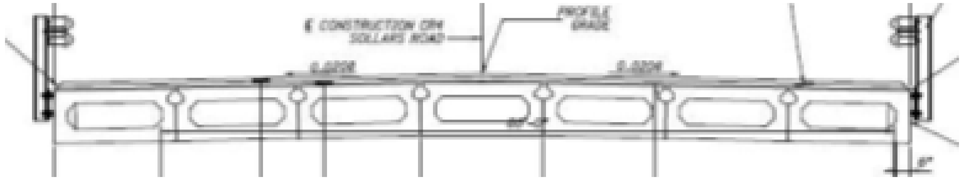
	# Bridges	PPVC	Initial Cost	Future Cost	Avg Length	Avg # Spans	Avg Year Built	Avg Life
Steel I Beam	27	$266.24	$222.08	$0.16	84	1.26	1978	82
Steel I Girder	18	$311.26	$257.19	$0.29	119	1.00	1977	81
P/S Box - Adjacent	240	$292.38	$235.03	$0.95	69	1.09	1987	74
P/S Box - Spread	325	$272.20	$225.14	$2.16	64	1.23	1986	81
P/S I Beam	98	$281.64	$231.20	$0.05	104	1.08	1987	77

↑

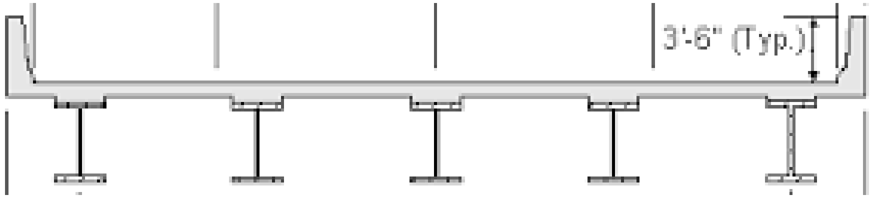
Steel Rolled
Precast Box Spread

All are "similar" with None "Way Out" of Balance

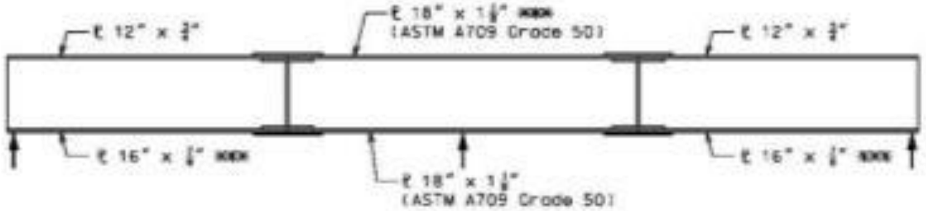
Which Type of Bridge is Best?



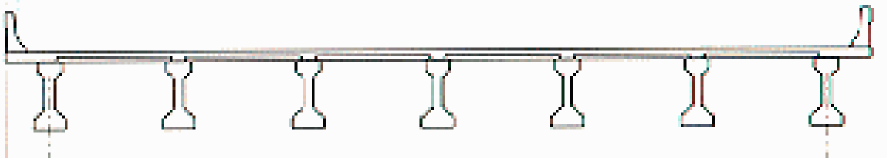
Precast Box Adjacent



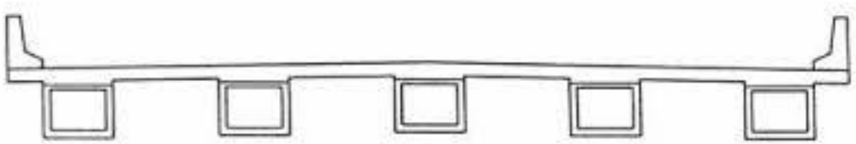
Steel Rolled Beam



Steel Plate Girder



Precast I Beam



Precast Box Spread

Which Type of Bridge is Best?

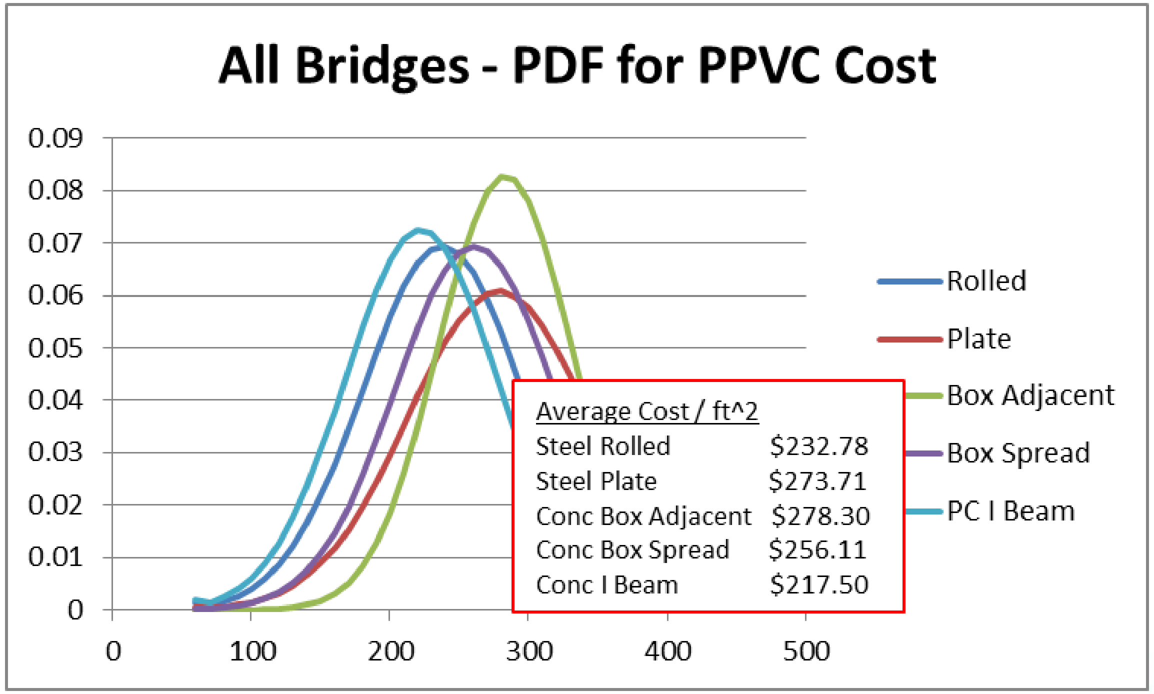
All are “similar” with None “Way Out” of Balance

Overall Weighted Average PPVC = $252.40/ft^2 – Capitalized Costs

All Bridge Types within 14% of Weighted Average

Standard Deviation Range
$48.02/ft^2 - $65.60/ft^2
[COV ≈ 20% - 25%]

Any One Type of Bridge May Be Most Economical for a Given Bridge Project



There is No One Type of Bridge That Clearly Beats the Others

Conclusions

Typical Concrete and Steel Bridges are Competitive on Initial Cost, Future Costs, Life Cycle Costs and Bridge Life

Owners Should Consider Both Steel and Concrete Alternatives for Individual Bridge Projects

But, there were no Galvanized Bridges in the Database

What About Galvanized Steel Bridges?

Steel Girder Protection Systems: Painting, Weathering Steel & Galvanizing

Galvanizing has become an economical and effective protection system

- Initial costs about equal to or even less than quality three-coat paint system
- Significantly increases the life of a steel bridge
- Near zero future maintenance

The objective of this study was to develop useful owner information on the effects of galvanizing on the historical Life Cycle Costs for typical bridges

– Sponsored by US Bridge, Cambridge, Ohio

Galvanized Steel Bridge Database

Painted steel bridges in the current database were modified by assuming the steel had been galvanized instead of painted when built

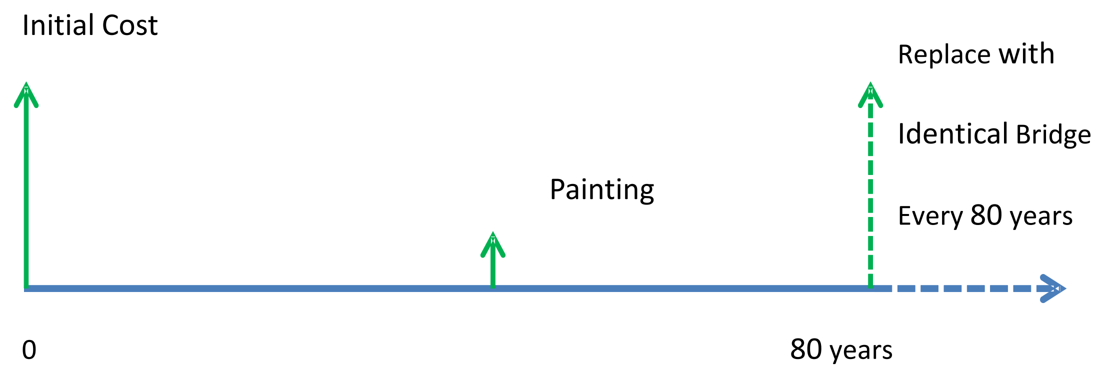
Assumptions:

- Galvanization adds 25 years to each bridge life
- Galvanizing costs are the same as a quality paint system, therefore bridge initial costs do not change
- Future painting costs are removed from the maintenance record
- Corrosion repairs to girders are removed from the maintenance record
- Concrete deck and joint repairs and other maintenance work remain in the maintenance record

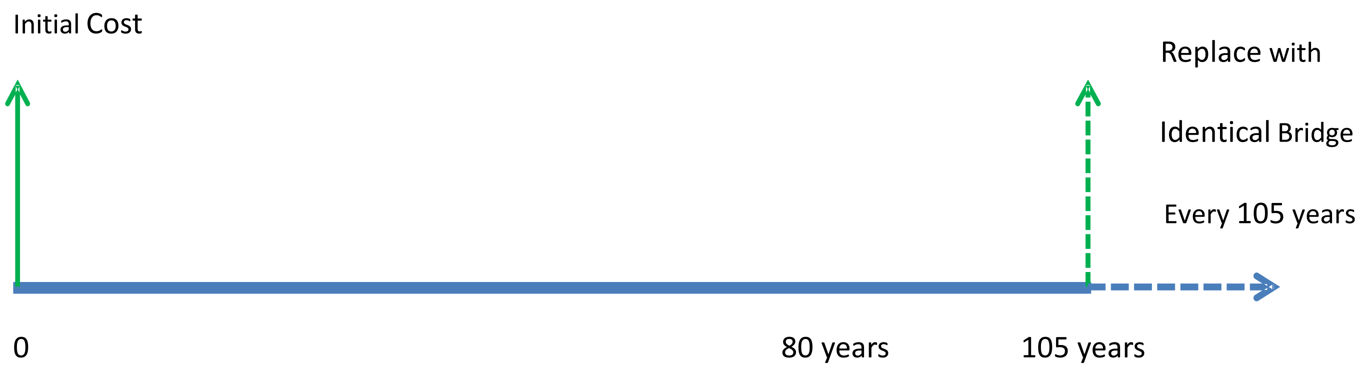
Galvanized Steel Bridge Life Cycle Costs

Benefits: Extended Life
Reduced Future Maintenance

Painted Girders



Galvanized Girders
+ 25 years



Rolled Beam vs Concrete – Length<140 ft

Short Length Bridges

	# Bridges	PPVC	Initial Cost	Future Cost	Avg Length	Avg # Spans	Avg Year Built	Avg Life
Steel I Beam (Painted)	18	$277.34	$230.66	$0.18	81	1.33	1980	82
Steel I Beam (Galvanized)	**18**	**$254.46**	**$230.66**	**$0.07**	**81**	**1.33**	**1980**	**107**
P/S Box - Adjacent	240	$292.38	$235.03	$0.95	69	1.09	1987	74
P/S Box - Spread	325	$272.20	$225.14	$2.16	64	1.23	1986	81
P/S I Beam	98	$281.64	$231.20	$0.05	104	1.08	1987	77

Steel Galvanized
Precast Box Spread
Steel Painted

Steel Galvanized
Steel Painted
Precast Box Spread

Summary

Typical Steel & Concrete Bridges are Competitive on First Cost

Typical Steel & Concrete Bridges are Competitive on Life Cycle Costs

Galvanizing:

- Is Economical for First Costs
- Extends the Life of Steel Bridges
- Reduces Future Maintenance Costs
- Can Lower Agency Life Cycle Costs

Owners Should Consider Both Steel and Concrete Alternatives for Individual Bridge Projects

Today’s Steel Bridges

State of the Art

- Light Weight, permits lighter equipment
- Local Crew Installation
- Close Tolerances, more efficient erection
- Longer Spans, minimize disruption underneath

Durable

- Robust, highly resistant to extreme natural disasters
- Weathering Steel, Galvanizing, Metalizing, Painting and 50CR (Stainless) produce Long Life
- Long Life, many steel bridges well over 100 years old

Today's Steel Bridges

Speed of Construction – Accelerated Bridge Construction

- Wide Range of Modular/Prefabricated Steel Bridges, install in a weekend
- Lighter Equipment, Ease of Erection

Cost Effectiveness

- Competitive with Other Bridge Materials
- Whole Project Savings, lighter abutments, smaller equipment, fast installation
- Weathering Steel, Galvanizing, Metalizing & 50CR Steel, can reduce initial costs and life cycle costs

Today’s Steel Bridges

Sustainability

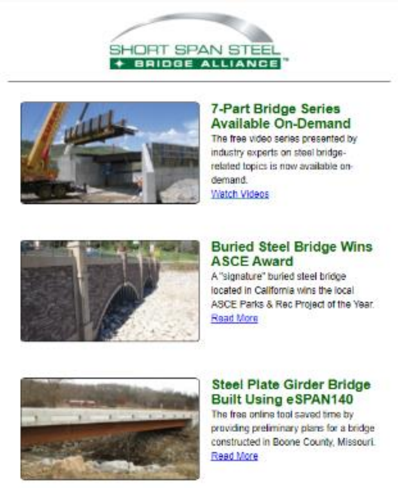
- Steel is North America’s #1 Recycled Material – over 90% of steel in a beam is from recycled materials
- Recycled Steel Conserves Energy, enough to power 18 million homes
- Steel’s Energy Use Reduced 33% Since 1990
- Greenhouse Gas Emissions Reduced by 45% since 1975

Resiliency

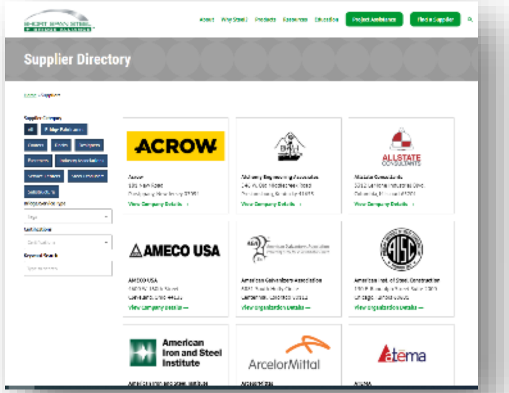
- Long Service Life
- Ease of Inspection
- Ease of Repair
- Strengthening for Increased Loads
- Recycling & Repurposing
- Habitat Protection

5 Ways to Keep Learning About Steel Bridges

1. Subscribe to the Weekly Newsletter



2. Find a Supplier



3. Design a Bridge in 5-Minutes

4. Receive Free Project Assistance

5. Schedule a Workshop/Webinar

www.ShortSpanSteelBridges.org

Questions? Dan Snyder, Director, SSSBA, dsnyder@steel.org, (301) 367-6179

Website: ShortSpanSteelBridges.org
Twitter: @ShortSpanSteel
Facebook: Short Span Steel Bridge Alliance