Steel Bridges for Tribal Communities

National Transportation in Indian Country Conference
Anchorage, Alaska
September 26, 2023

Dr. Michael G. Barker, PE
University of Wyoming &
SSSBA, Director of Education

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 Girders

Buried Bridges

Truss

Press Brake & Folded Plate

Short Span Steel Bridge Alliance – Why We Are

Remove Design Obstacles for Short Span Steel Bridges

Overcome Preconception that Concrete is Always Less Expensive in Short Span

Prefabricated Manufactured Steel Bridge Systems and Accelerated Bridge Construction

Develop and Implement Innovative Steel Bridge Systems

Educate Owners, Engineers & Students in Steel Bridge Design

SSSBA – Members

Producers

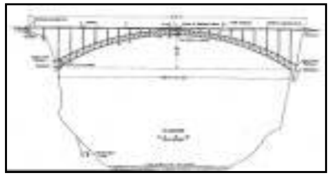
Fasteners

Coaters

Service Centers

Fabricators

SHORT SPAN STEEL
BRIDGE ALLIANCE ™



Design Firms

Contractors

NATIONAL ASSOCIATION NACE COUNTY ENGINEERS

Bridge Owners

Universities

AGA American Galvanizers Association

NCSPA

American Iron and Steel Institute

NSBA

Trade Organizations

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

ShortSpanSteelBridges.org

SSSBA Education – The 5 Cs

Cost
- Case Studies
- Cost Studies
- Life Cycle Costs
- Economical & Practical Design

Convenience
- eSPAN140
- Standard Designs
- State Standards
- SIMON

Construction
- Accelerated Bridge Construction
- Case Studies / Manufacturer Solutions
- Equipment

County Built
- DIY County Bridges
- Case Studies

Carbon – CO_2e
- Sustainability of Rural Bridges

Resiliency Coming Soon

Today's Session

eSPAN140 Design Tool – *Steel Bridge Design Made Easy*

Bridge Manufacturer Solutions/ABC – *I Need a Bridge, Bring Me One*

Initial Costs – *Dealing with the Preconception on Steel Bridge Costs*

Life Cycle Cost Comparison Steel vs Concrete – *Long Term Performance & Costs*

Sustainability – Carbon Footprint

Local Crews Building Tribal Transportation Facility (TTF) Bridges – Saving $ and Developing Tribal Workforce

Resources & Opportunities Through the Short Span Steel Bridge Alliance

We Only Have Time to Quickly Address These Today:
More Information and Reports at 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

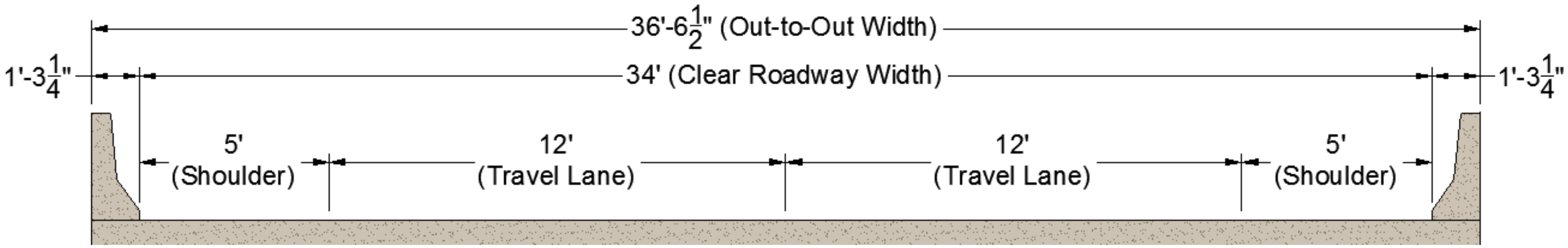
Press-Brake Tub Girder

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:

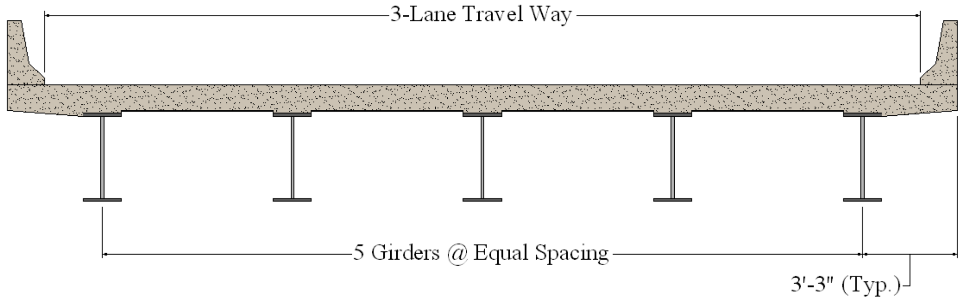
- Strength I,
- Service II,
- Fatigue,
- Constructability,
- L/800 Deflection
- HL-93 Vehicular Live Loading

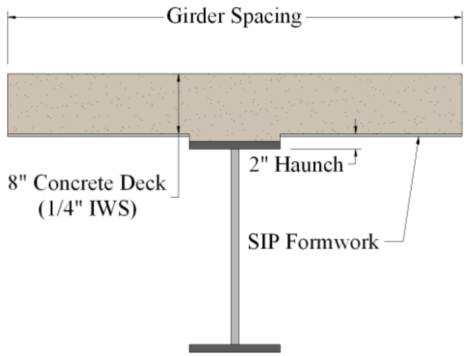
eSPAN140 - Standard Designs for Short Span Steel Bridges - www.ShortSpanSteelBridges.org

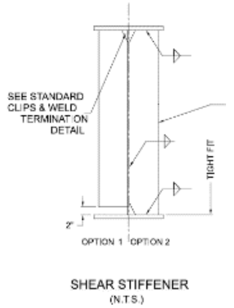
Span lengths 20 ft to 140 ft (in 5 ft increments)

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

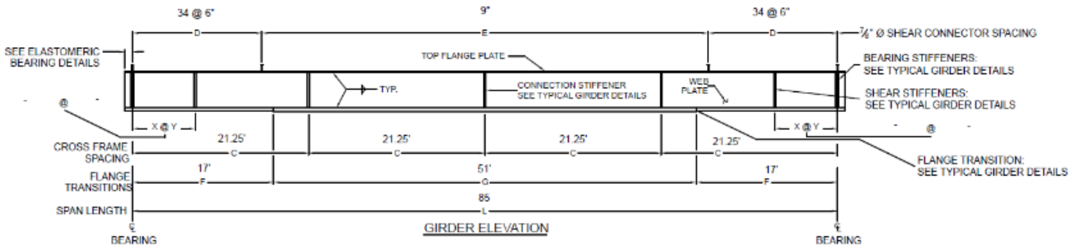
For each of these increments: Steel girders, Shear stud & stiffener layouts, Welding and fabrication details, Elastomeric bearings, and Concrete deck design

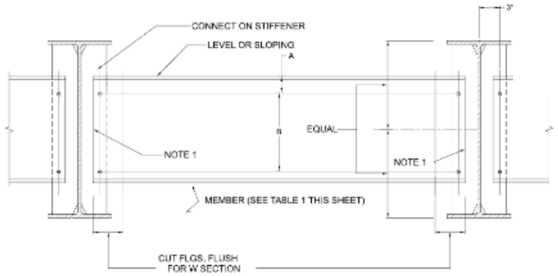






COMPOSITE PLATE GIRDER WITH PARTIALLY STIFFENED WEB - 4 GIRDERS AT 8' 10" GIRDER SPACING, HOMOGENEOUS





eSPAN140 Preliminary Design

Solution Type*	Bridge Span Length (0' 20' 40' 60' 80' 100' 120' 140')	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
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.

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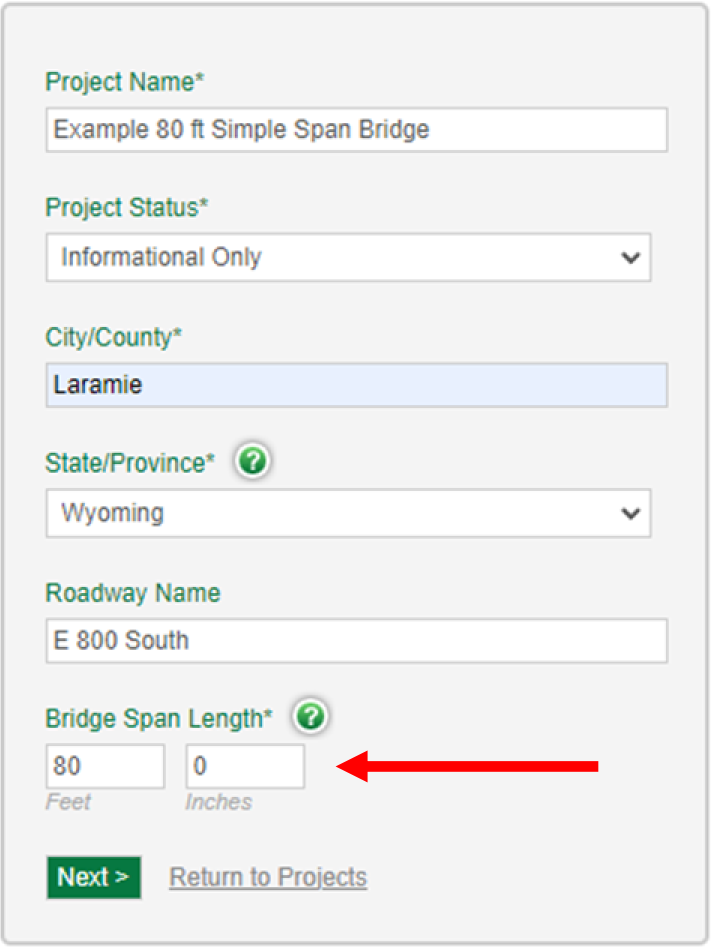
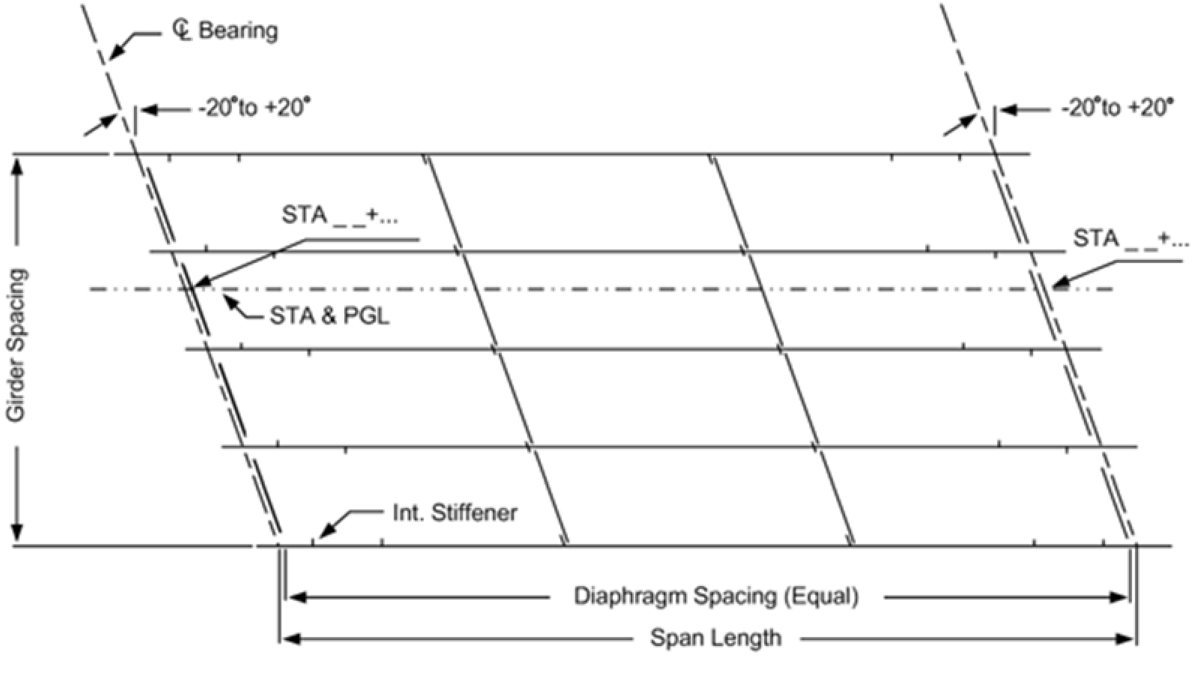
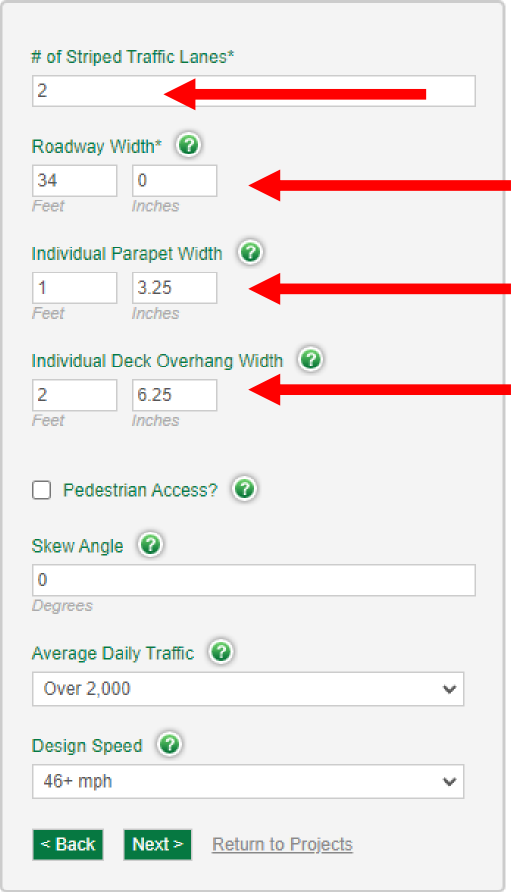
eSPAN140 Preliminary Design



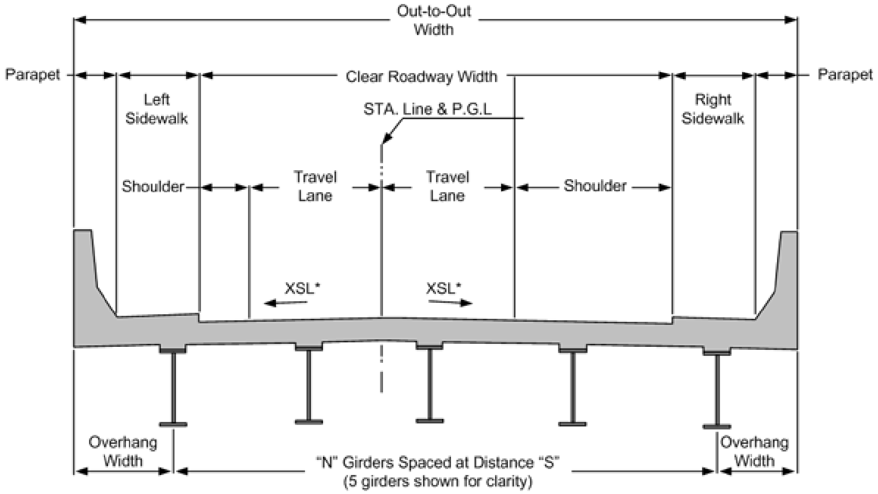


Skew Angle (Overhead View)

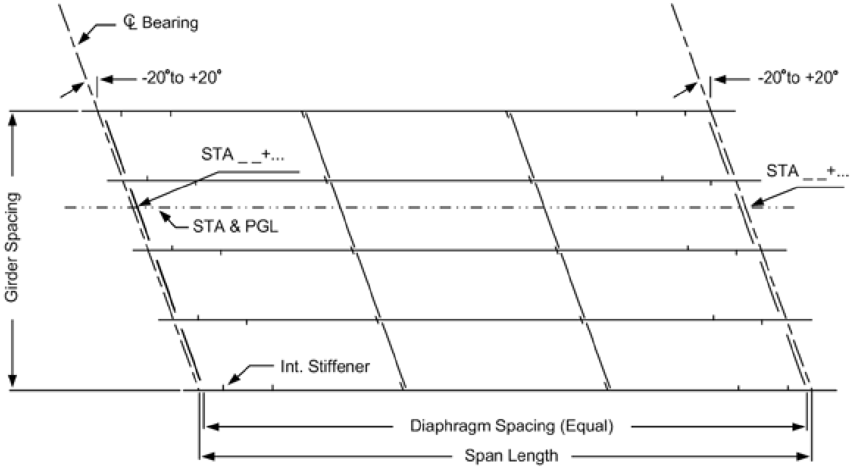
eSPAN140 Preliminary Design



* Required



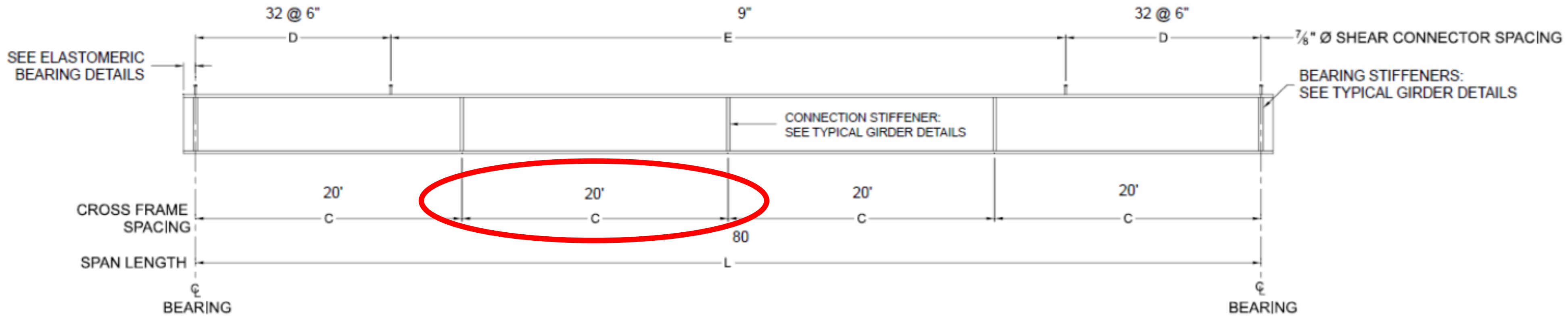
Cross-section of Bridge



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

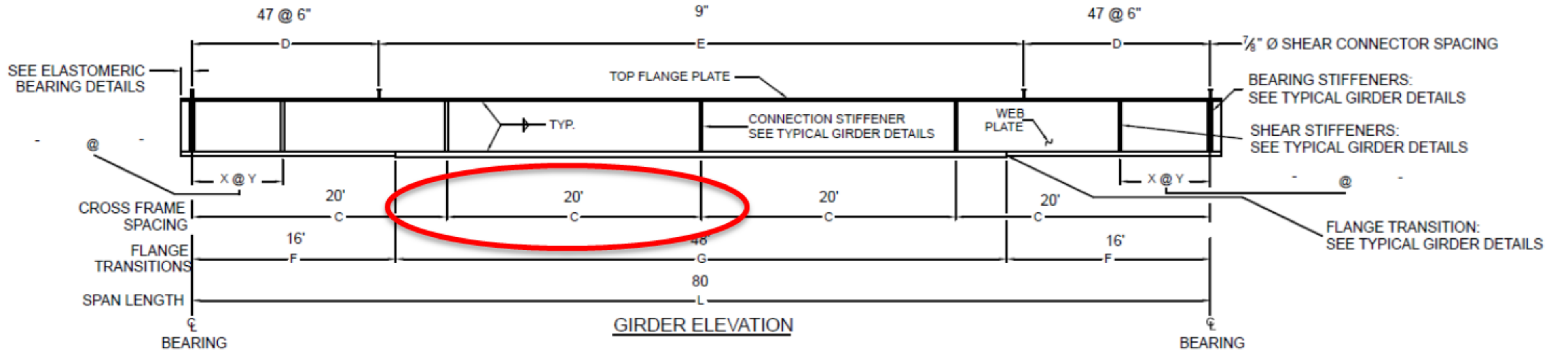
SPAN (L) - ft	ROLLED BEAM	DIAPHRAGM SPACING (C) - ft	SHEAR CONNECTOR MAX. SPACING		WEIGHT
			D	E	
80	W36x210	20'	32 @ 6"	9"	16,800 lbs

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

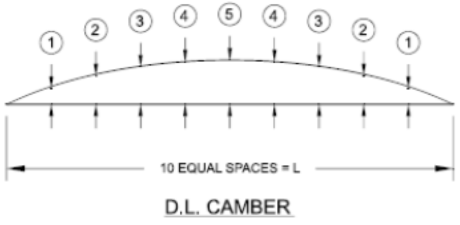
Plate Girder Recommendation

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

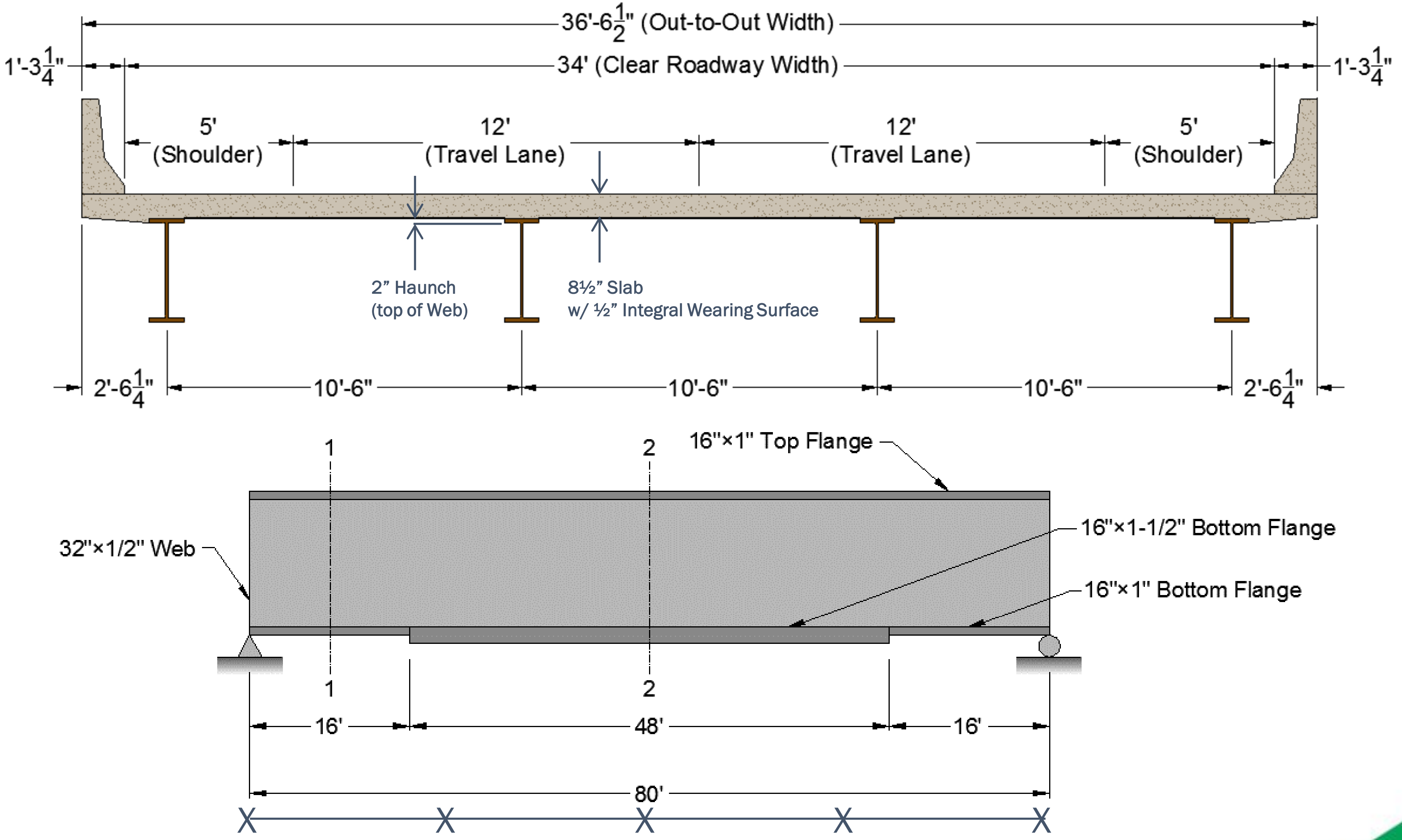


SPAN (L) - ft	PLATE GIRDER SIZE						DIAPHRAGM SPACING (C) - ft	SHEAR STIFFENERS		SHEAR CONNECTOR MAX. SPACING		INDIVIDUAL GIRDER WEIGHT
	TOP FLANGE - in	BOTTOM FLANGE (F)		BOTTOM FLANGE (G)		WEB PLATE- in		X (NO. REQ'd)	Y - ft. (SPACING)	D	E	
		PLATE - in	LENGTH - Ft	PLATE - in	LENGTH - Ft							
80	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"



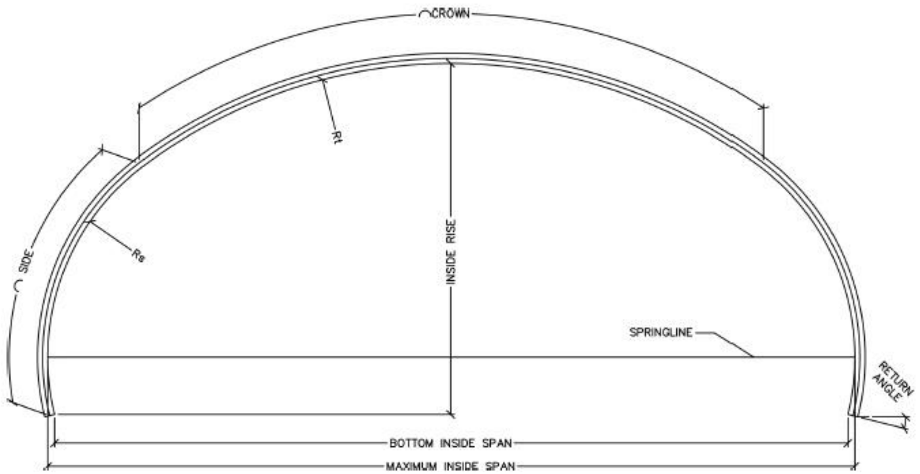
Design for Homogeneous Plate Girder Bridge



Lateral Bracing at 20 ft

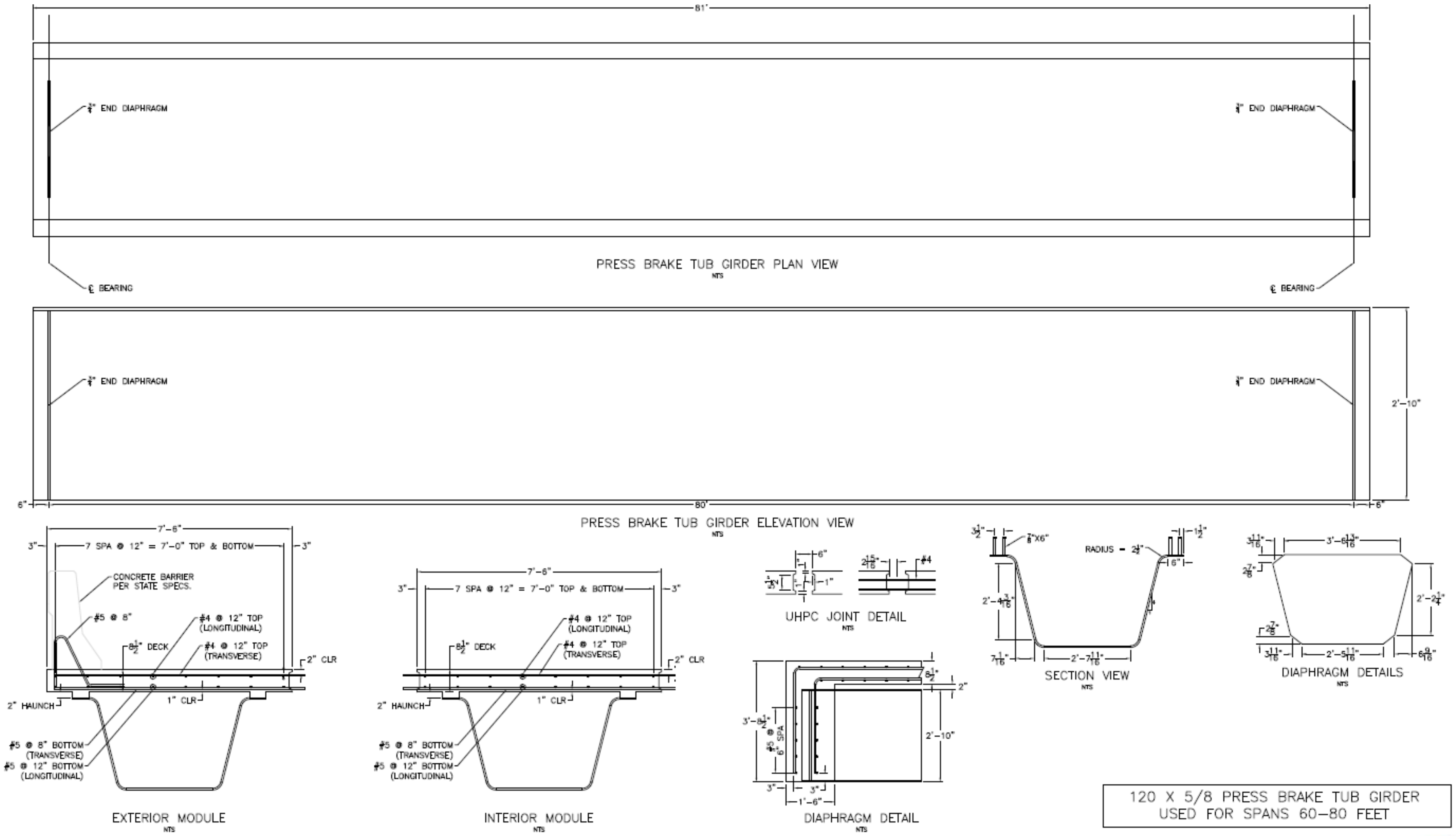
Buried Steel Bridge Recommendation

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



Result

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

eSPAN140 Design Tool – Manufacturer Solutions






PreFabricated Bridges – "Send Me A Bridge"

Benefits (FHWA Resource Center: Prefabricated Bridge Elements & Systems)

Time Savings: concurrent fabrication, construction & less weather issues

Cost Savings: reduced construction time, reduced traffic delays

Safety Advantages: reduced exposure to hazards

Increased Constructability: elements constructed off-site and put in place

Accelerated Bridge Construction: for most of the manufacturer solutions

Bridge-In-a-Box: convenience and aesthetics for owners

Accelerated Bridge Construction (ABC)

FHWA (http://www.fhwa.dot.gov/bridge/abc/):

"ABC is bridge construction that uses innovative **planning, design, materials, and construction methods** in a safe and cost-effective manner to reduce the onsite construction time that occurs when building new bridges or replacing and rehabilitating existing bridges."

ABC improves:

- Site Constructability
- Total project delivery time
- Work-zone safety for the traveling public

ABC reduces:

- Traffic Impacts
- Onsite construction time
- Weather-related time delays

Showcase of 3 Different Steel Bridges

Bridge Case Studies

- Buried Steel Bridge – Big R
- Modular Beam Bridge - Contech
- Press-Brake Tub Girder – Valmont

The 5 C's

Cost

Convenience

Construction (ABC)

County Built

Carbon Footprint

Buried Steel Bridge - Corrugated Steel Plate – Contractor Built

VT Route 2B Bridge Replacement, St. Johnsbury, VT

Contractor: JP Sicard

Fabricator: Big R Bridge

28 day max. trail closure / 50 day road closure for all work

Greeley, CO

47'11" span x 26'9" rise Arch

Buried Steel Bridge - Corrugated Steel Plate

Buried Steel Bridge - Corrugated Steel Plate

VT Route 2B Bridge Replacement, St. Johnsbury, VT

Deep Corrugated Steel Buried Bridges

I-44 over Entrance Ramp from Route 96

I-44 over CR 1147

Deep Corrugated Steel Buried Bridges

Craig, AK
Built by Tribal Workforce

Pre-Fabricated Modular Beam – County Crew Built

Seltice-Warner Bridge, White Road, Whitman County, WA

Fabricator: BigR/Contech Engineered Solutions
Contractor: Whitman County Crew
Design Engineer: Mark Storey, County Engineer

CONTECH ENGINEERED SOLUTIONS

Existing Structure – 30 ft Span, 20 ft Wide

- Built/Rebuilt 1952/1986
- Wood with Wood Piles & Wood Backwalls
- Wood Deterioration & Susceptibility to Scour

Replacement Structure Requirements

- Increase Hydraulic opening – 30 ft Channel
- Raise Clearance for 100 yr Flood
- Gravel Roadway
- Piles with Alluvium Soils / Scouring

Pre-Fabricated Modular Beam

Foundation and Abutment

County Owned Pile Driver (44 ton/pile)

H12x53 Pile Cap

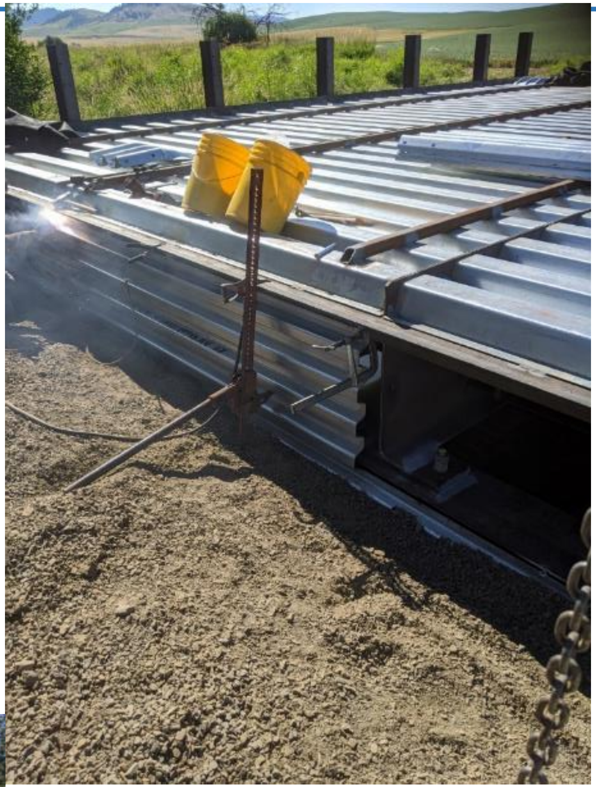
Pre-Fabricated Modular Beam

Bridge Structure

- 35 ft Span x 28 ft Wide
- 2-Girder Modules / 3 Modules
- Shipped on One Truck
- Fully-Assembled
- CSD & Gravel
- Simple Connections

Pre-Fabricated Modular Beam

SuperStructure Erection



Pre-Fabricated Modular Beam

Timing

Excavation, Stream Restoration & Bridge Installation ~ 4 Weeks

Costs

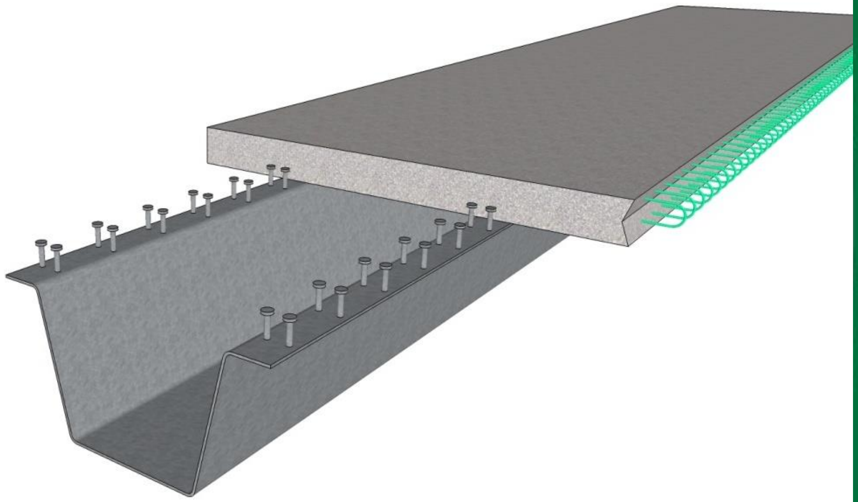
Steel Superstructure	$ **59,000**
Labor & Equipment	$ 70,000
Pile Foundations	$ 20,000
Permitting	$ 10,000
Total	$159,000

$ 162.25 / ft^2

Concrete Superstructure Alternative $ **82,000**

Press-Brake-Formed Steel Tub Girders

- Modular shallow trapezoidal boxes fabricated from cold-bent structural steel plate
  - Weathering steel or galvanized.
- Reduction in fabrication costs due to cold-bending versus welding of the section and mass production.
- Reduces need for stiffeners and cross frames.
- Advantages include:
  - Accelerated with precast deck (install in 1 or 2 days)
  - Modular
  - Simple to fabricate and install



SSSBA Research Started in 2012
First PBTG Bridge Built in 2015
(However, Michigan Installed One in 2004)

Press-Brake Tub Girder – Contractor Built

Barron County, WS

Fabricator: Valmont
Contractor: Larson Construction

Existing Structure

3-Span Timber Slab
96 ft Length
Deterioration and Deficient

Replacement Structure Requirements

Two Span
104 ft Length
Increased Hydraulic Opening and Clearance

#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.

valmont STRUCTURES

#2 AASHTO FORMING

valmont STRUCTURES

AASHTO 11.4.3.3 - Bent Plates

Fracture-critical and Non-fracture critical plates and bars shall be cold bent.

#3 AASHTO CAMBERING

valmont
STRUCTURES

AASHTO 11.4.12.2.7

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

#4 AASHTO WELDING AND SHEAR STUDS

valmont STRUCTURES

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)

Construction Pictures – Steel PBFTG

Construction Pictures – Deck Forms

COOPER ENGINEERING

Construction Pictures – Deck Pour

COOPER ENGINEERING

Construction Pictures – Finished

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	Concrete

<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

<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
20º 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

Superstucture Costs	
Material	
Girders	= $ 21,463
Deck Panels	= $ 7,999
Reinf Steel	= $ 3,135
Concrete	= $ 4,180
Labor	= $ 5,522
Equipment*	= $ 500
SUPER TOTAL	= $ 42,799

SUPER TOTAL = $37.54 / sq. ft.

Concrete

Superstructure Costs	
Material	
Slab Girders	= $ 50,765
Deck Panels	= $ 0
Reinf Steel	= $ 724
Concrete	= $ 965
Labor	= $ 4,884
Equipment*	= $ 4,000
SUPER TOTAL	= $ 61,338

SUPER TOTAL = $50.61 / sq. ft.

*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	712-3				
1910	715-1				
1920	716-10				
1930	716-10				$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 1.1[illegible]9 =	$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**

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 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

Steel: Superstructure $37.54 per sq. ft. **Concrete: Superstructure Cost $50.61 per sq. ft.**

Same bridge conditions:

- 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

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

Kansas Department of Transportation

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

WORKLOOKER BOONE COUNTY

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

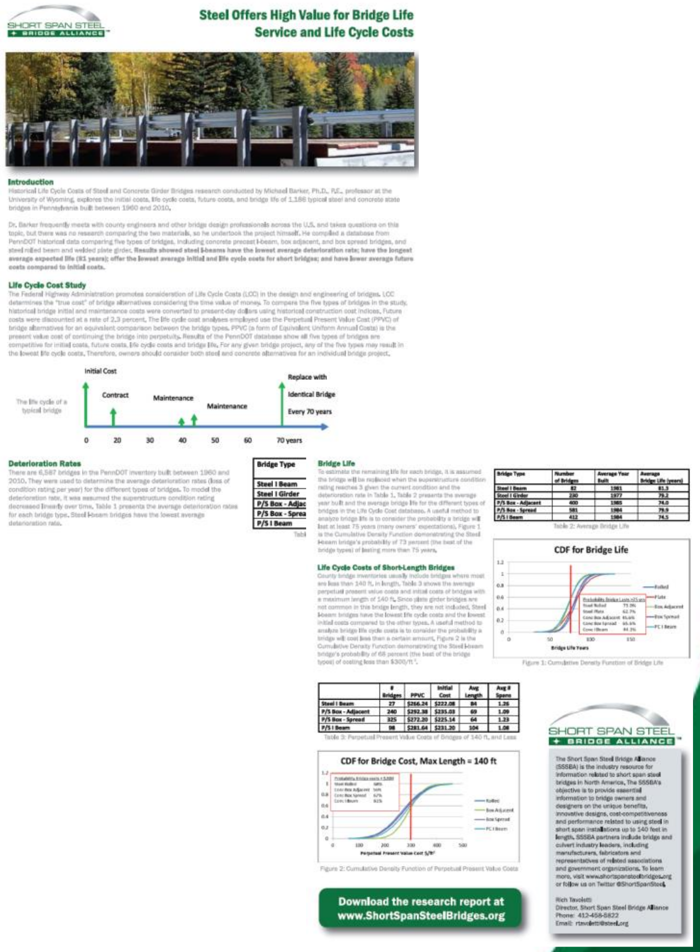
The bridge industry ~~does~~ did not have a good answer:

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



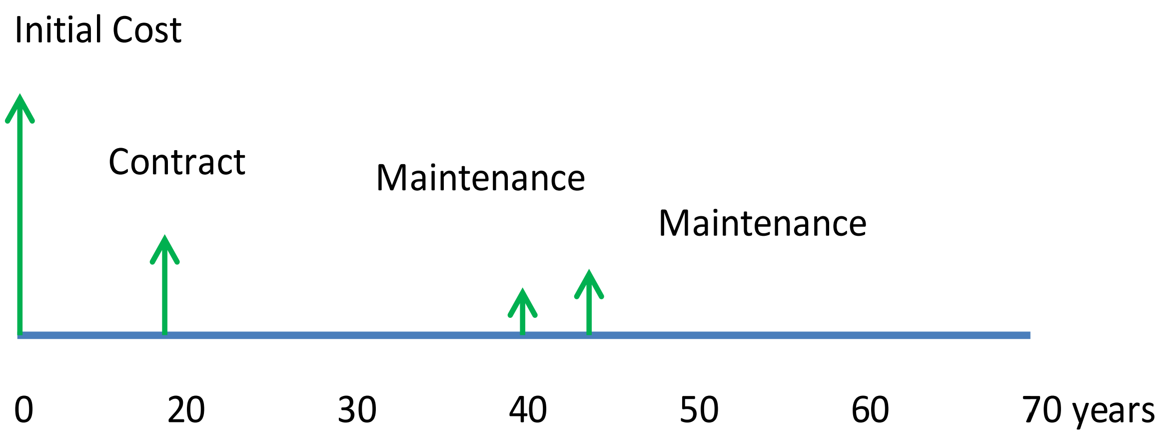
Report on ShortSpanSteelBridges.org

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 Stepped Up to Participate

PennDOT Database Development

<u>Criteria to Develop LCC Bridge Database</u>

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**

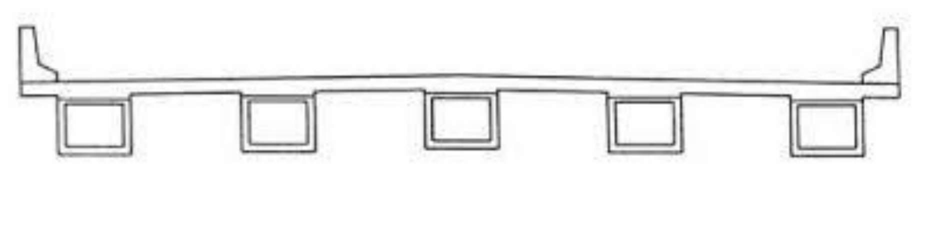
↑ Steel Rolled
Precast Box Spread

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

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

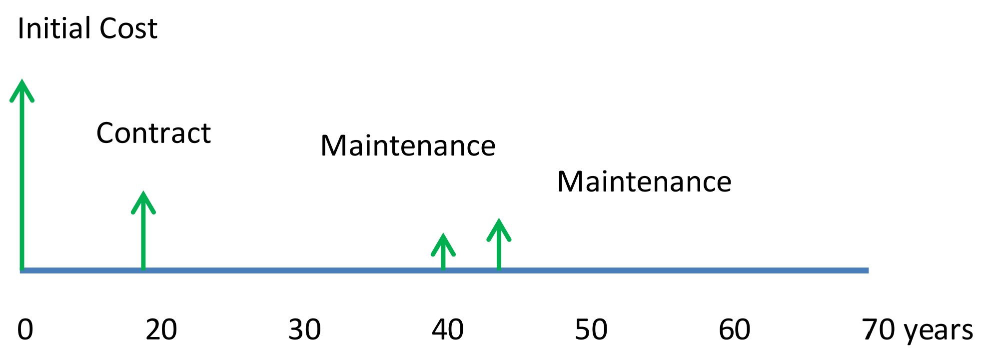
Transform the costs to constant 2014 dollars using Construction Cost

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



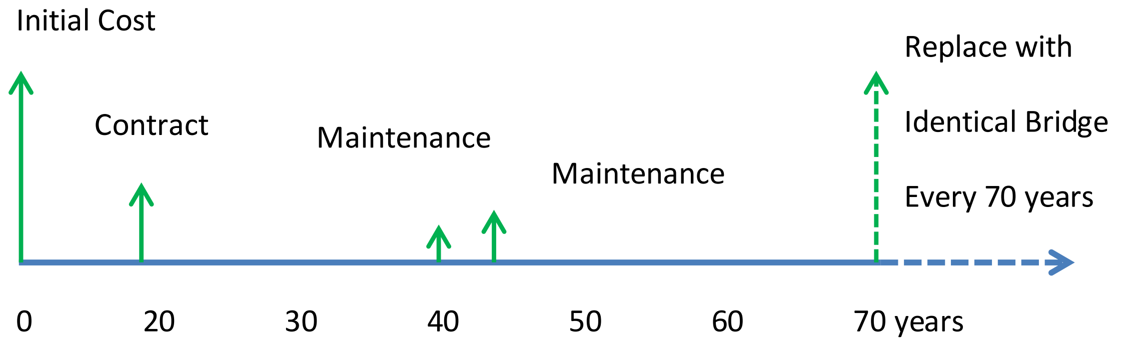
Present Value Cost for 1 Cycle

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

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

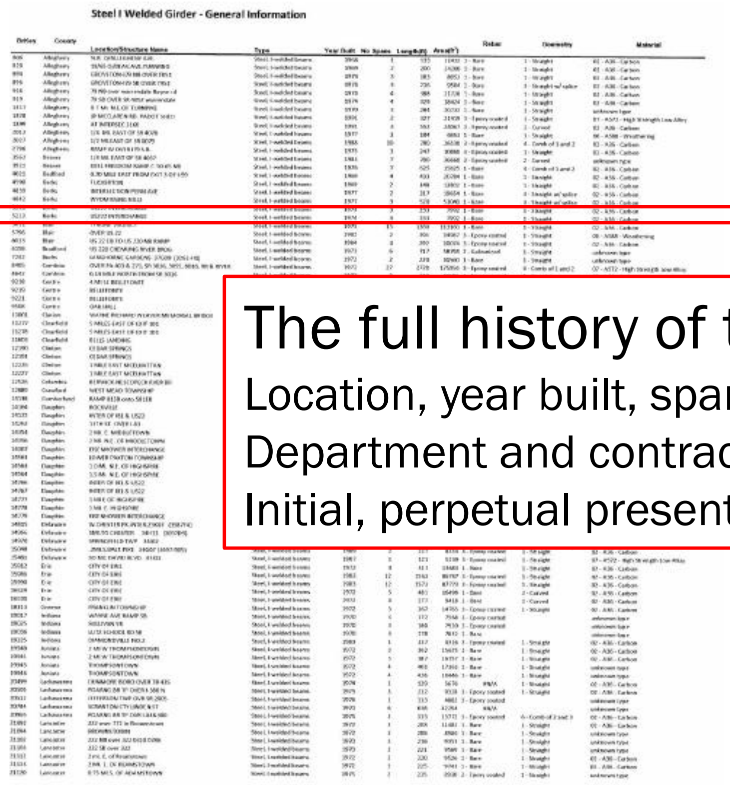
$$PPVC = \$154.49\left[\frac{(1+0.023)^{70}}{(1+0.023)^{70}-1}\right] = 1.256(\$154.49) = \$193.97/ft^2$$

With Capitalized Costs, Can Compare Bridges Directly

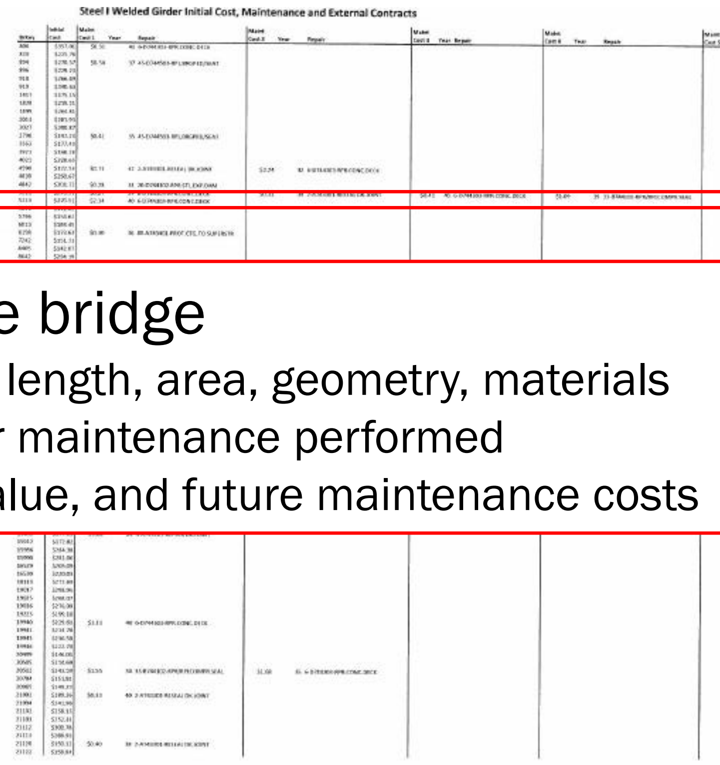
Life Cycle Cost Analyses

The Steel Plate Girder Bridge Data Base

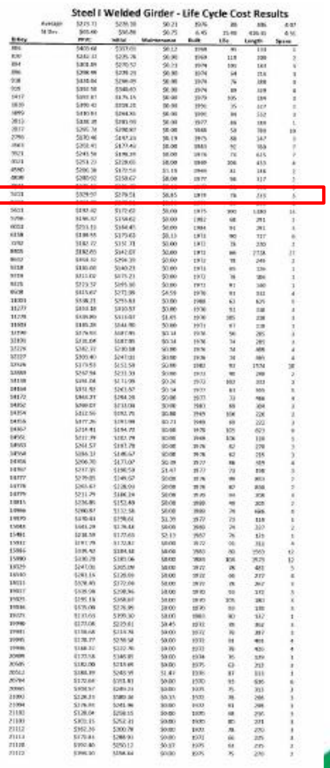
General Information



Maintenance & Contract Work



Initial & LCC



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

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

Life Cycle Costs– Length<140 ft

Short Length Bridges
Short Span Steel Bridge Alliance

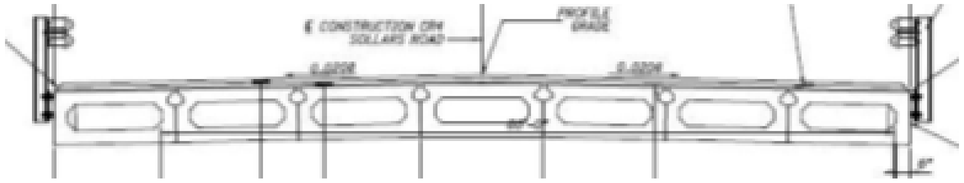
	# Bridges	PPVC	Initial Cost	Future Cost	Avg Length	Avg # Spans	Avg Year Built	Avg Life
Steel I Beam	27	$266.24	$222.08	$0.16	84	1.26	1978	82
Steel I Girder	18	$311.26	$257.19	$0.29	119	1.00	1977	81
P/S Box - Adjacent	240	$292.38	$235.03	$0.95	69	1.09	1987	74
P/S Box - Spread	325	$272.20	$225.14	$2.16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

↑

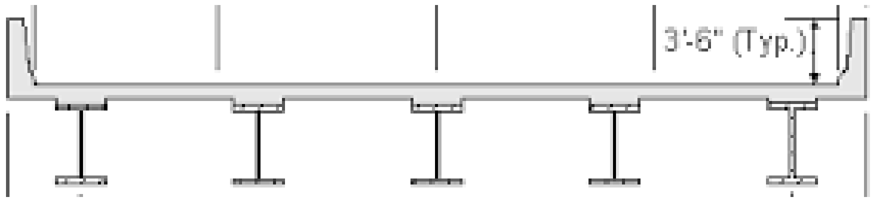
Steel Rolled
Precast Box Spread

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

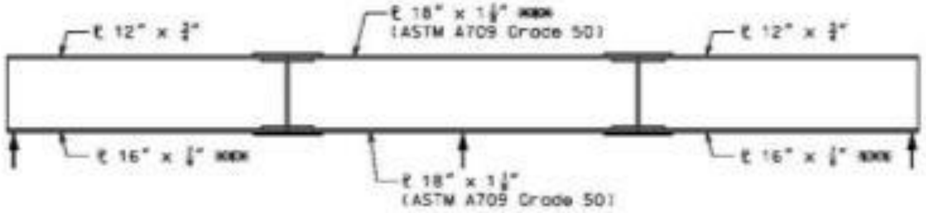
Which Type of Bridge is Best?



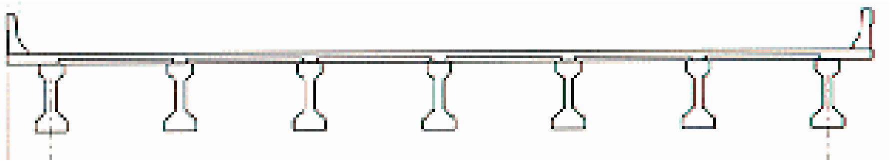
Precast Box Adjacent



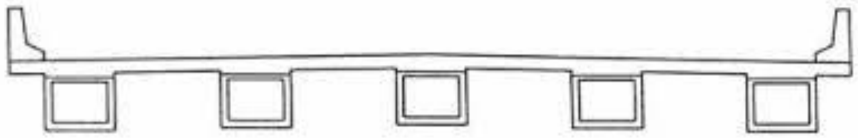
Steel Rolled Beam



Steel Plate Girder



Precast I Beam



Precast Box Spread

Which Type of Bridge is Best?

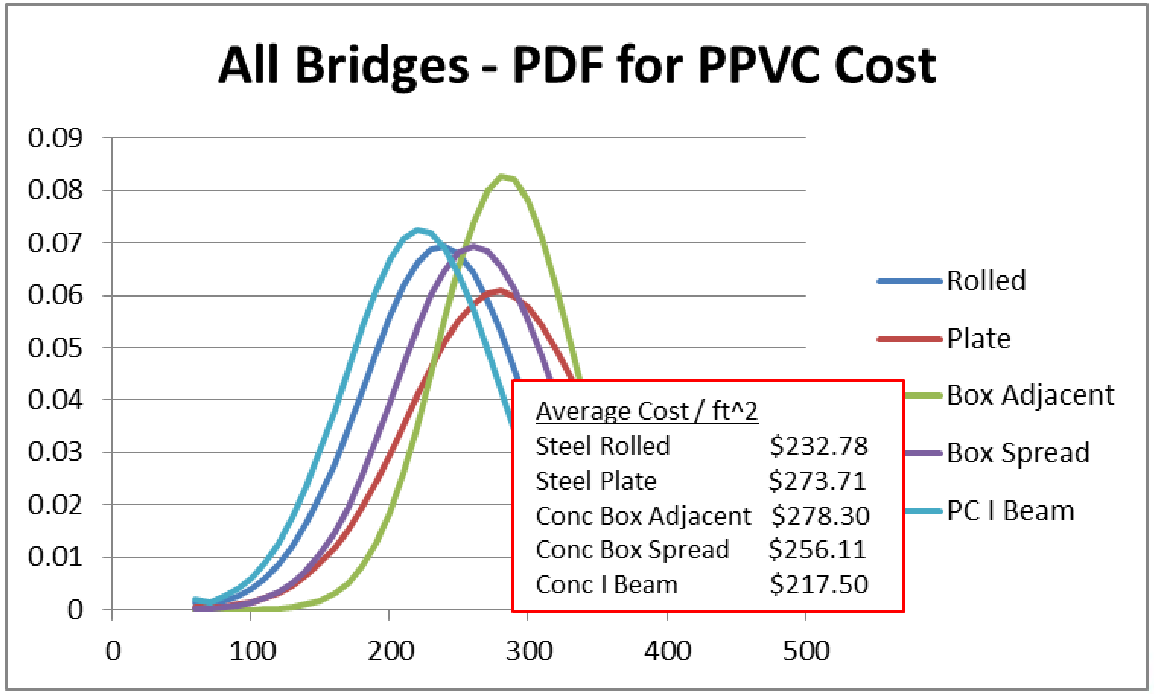
All are "similar" with None "Way Out" of Balance

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

What About Sustainability? – Bipartisan Infrastructure Law $13 Billion to Tribal Bridges

Incorporating Sustainability for Bridge Decision Making

- Life Cycle Sustainability Assessment (Cradle to Grave) of Two Nearly Identical, Functionally Equivalent, Two-Lane Bridges from Whitman County, WA
  - Steel – Seltice-Warner
    - Built 2020, 35 ft – 8 in, Modular Steel, 7 Rolled Beams, Corrugated Gravel Deck, County Crew Built
  - Concrete – Thornton Depot
    - Built 2019, 34 ft – 0 in, Precast Prestressed Beams, 8 Beams, Concrete Deck, County Crew Built
- Develop Procedures for Owners or Society that Considers Sustainability Benefits for the Design of Bridges

Bridges – Life Cycle

Steel Seltice-Warner

- Superstructure
- Construction
- Maintenance
- Demolition

Concrete Thornton Depot

- Superstructure
- Construction
- Maintenance
- Demolition

Superstructure Only

Bridge Lifes 75 yrs

Prefabricated Bridges and Installation Equipment and Costs

Maintenance Assumed Identical for Both Bridges (none for 25 yrs, yearly for 50 yrs)

Demolition Equipment and Costs Different for the Two Bridges

Process

- Life Cycle Sustainability Assessment
  - Establish Criteria and Benchmarks
  - CO_2e, Energy, Recycling & Wastestream Metrics, Life Cycle Costs
  - Life Cycle Bridge Results
- Procedure that Considers Sustainability Benefits for the Design of Bridges
  - Monetizing Sustainability Benefits
  - Equivalent Cost Decision Making

Emissions and Energy Consumption Metrics

- Fabricated Material and Component Emissions & Energy Consumption Metrics from Environmental Product Declarations (EPDs).
- Equipment Emissions & Energy Consumption Metrics from Analysis

Material	Description	Emissions (kgCO2e/ton)	Energy Consumption (MJ/ton)
Concrete	Precast Concrete Component	310.3	3268
	Grout	614.2	4545
Steel	Hot Rolled Steel Shapes	1106.8	16840
	Plates	1569.4	20804
	Steel Tubes	2168.2	25611
	Steel Deck	2150.0	27208
	Guardrail*	2150.0	27208
Other	#7 Gravel (1/2" x #4)	1.41	30.8

Construction Equipment	Description	Emissions (kgCO2e/hr)	Energy Consumption (MJ/hr)
Equipment	Light Equipment	50.8	724.5
	Heavy Equipment	71.1	1014.3

Superstructure Emissions and Energy Consumption

Steel Seltice-Warner

Bridge Component:	Weight (tons):	Emissions (kgCO2e/ton)	Energy (MJ/ton)	Length Factor	Emissions (kgCO2e)	Energy (MJ)
Stringers	9.337	1,106.8	16,840.1	0.953	9,851	149,892
Diaphragm	0.916	1,106.8	16,840.1	1.000	1,013	15,418
Tubes	0.308	2,168.2	25,610.8	0.953	637	7,523
Center Splice Plate	0.152	1,569.4	20,803.6	1.000	239	3,172
Side Dam	0.244	1,569.4	20,803.6	0.953	365	4,838
End Angle	0.274	1,106.8	16,840.1	1.000	304	4,621
Bridge Deck	4.699	2,150.0	27,208.3	0.953	9,631	121,880
Guardrail	0.360	2,150.0	27,208.3	0.953	737	9,328
Bridge Rail Post	0.578	1,106.8	16,840.1	1.000	639	9,725
Post Block	0.096	1,106.8	16,840.1	1.000	107	1,621
Gravel	22.655	1.4	30.8	0.953	30	665
Steel Weight	**16.96**			**Sub-Total Superstructure**	**23,554**	**328,683**
Reinf Concrete Weight	**-**					

Concrete Thornton Depot

Bridge Component:	Weight (tons):	Emissions (kgCO2e/ton)	Energy (MJ/ton)	Length Factor	Emissions (kgCO2e)	Energy (MJ)
Precast Elements	103.840	310.3	3,267.7	1.000	32,217	339,316
Misc. Steel Detail Items	0.338	2,150.0	27,208.3	1.000	727	9,196
Grout	0.999	614.2	4,545.0	1.000	614	4,540
Guardrail	0.360	2,150.0	27,208.3	1.000	773	9,785
Bridge Rail Post	0.387	1,106.8	16,840.1	1.000	428	6,517
Steel Weight	**1.08**			**Sub-Total Superstructure**	**34,759**	**369,355**
Reinf Concrete Weight	**103.84**					

Equipment Emissions and Energy Consumption

Steel Seltice-Warner

Construction Equipment	Hours on Site	Emissions (kgCO2e/hr)	Energy (MJ/hr)	Usage Factor	Emissions (kgCO2e)	Energy (MJ)
Heavy Equipment	130	71.1	1,014.3	0.30	2771	39558
Light Equipment	105	50.8	724.5	0.30	1599	22822
				Sub-Total Construction	**4,370**	**62,379**

Maintenance	Hours on Site/yr	Emissions (kgCO2e/hr)	Energy (MJ/hr)	Usage Factor	EoL Yrs of Maint	Emissions (kgCO2e)	Energy (MJ)
Heavy Equipment	3	71.1	1,014.3	1.00	50	10658	152145
Light Equipment	3	50.8	724.5	1.00	50	7613	108675
				Sub-Total Maintenance		**18,270**	**260,820**

Demolition	Hours on Site	Emissions (kgCO2e/hr)	Energy (MJ/hr)	Usage Factor	Emissions (kgCO2e)	Energy (MJ)
Heavy Equipment	20	71.1	1,014.3	0.50	711	10143
Light Equipment	15	50.8	724.5	0.50	381	5434
				Sub-Total Yearly Demolition	**1,091**	**15,577**

Concrete Thornton Depot

Construction Equipment	Hours on Site	Emissions (kgCO2e/hr)	Energy (MJ/hr)	Usage Factor	Emissions (kgCO2e)	Energy (MJ)
Heavy Equipment	128	71.1	1,014.3	0.30	2728	38949
Light Equipment	134	50.8	724.5	0.30	2040	29125
				Sub-Total Construction	**4,768**	**68,074**

Maintenance	Hours on Site/yr	Emissions (kgCO2e/hr)	Energy (MJ/hr)	Usage Factor	EoL Yrs of Maint	Emissions (kgCO2e)	Energy (MJ)
Heavy Equipment	3	71.1	1,014.3	1.00	50	10658	152145
Light Equipment	3	50.8	724.5	1.00	50	7613	108675
				Sub-Total Maintenance		**18,270**	**260,820**

Demolition	Hours on Site	Emissions (kgCO2e/hr)	Energy (MJ/hr)	Usage Factor	Emissions (kgCO2e)	Energy (MJ)
Heavy Equipment	40	71.1	1,014.3	0.50	1421	20286
Light Equipment	20	50.8	724.5	0.50	508	7245
				Sub-Total Yearly Demolition	**1,929**	**27,531**

Life Cycle Emissions and Energy Consumption

Emissions

Emissions (kgCO2e)					
	Superstructure	Construction	Maintenance	Demolition	Total
Steel	23554	4370	18270	1091	47284
Concrete	34759	4768	18270	1929	59726

Steel 68% Less Same Less 79%

Energy Consumption

Energy (MJ)					
	Superstructure	Construction	Maintenance	Demolition	Total
Steel	328683	62379	260820	15577	667459
Concrete	369355	68074	260820	27531	725780

Steel 89% Less Same Less 92%

RESULTS – Steel Bridge Has Sustainability Advantages

Recycling, Surplus and Landfill

- Recycling Surplus or Cost
  98% Steel Recycled at Surplus of $100/ton
  80% of Concrete Recycled at Cost of $4.10/ton
- Landfill Cost $75/ton

Bridge	Steel Weight (tons)	% Steel Recycled	Concrete Weight	% Concrete Recycled	Steel Recycled (tons)	Concrete Recycled (tons)	Steel to Landfill (tons)	Concrete to Landfill (tons)
Steel	16.96	98%	-	80.0%	16.62	0.00	0.34	0
Concrete	1.08	98%	103.84	80.0%	1.06	83.07	0.02	20.768

Seltice-Warner Salvage Payback and Landfill Costs	
Tons of Steel Recycled	16.62
Tons of Steel to Landfill	0.34
Recycling Payback	$1,662.49
Landill Cost	$25.45

Thornton Depot Salvage Payback and Landfill Costs	
Tons of Steel Recycled	1.06
Tons of Steel to Landfill	0.02
Tons of Concrete Recycled	83.07
Tons of Concrete to Landfill	20.77
Recycling Cost	$234.30
Landill Cost	$1,559.23

Present Value of Costs (OMB Discount Rate 1.70%)

Steel Seltice-Warner

Bridge Component:	Costs	Length Factor	Adjusted Costs	Present Value Cost
Prefabricated Bridge	$ 60,134.00	0.953	$ 57,323.95	$ 57,323.95
Labor	$ 8,750.00	1.000	$ 8,750.00	$ 8,750.00
Equipment	$ 8,255.00	1.000	$ 8,255.00	$ 8,255.00
Materials	$ 3,491.00	0.953	$ 3,327.87	$ 3,327.87
		Sub-Total Superstructure	**$ 77,656.81**	**$ 77,656.81**

Demolition	Costs	Length Factor	Adjusted Costs	Present Value Cost
Labor	$ 5,000.00	1.000	$ 5,000.00	$ 1,412.21
Equipment	$ 1,110.00	1.000	$ 1,110.00	$ 313.51
Salvage	$ (1,662.49)	0.953	$ (1,584.81)	$ (447.61)
Landfill	$ 25.45	0.953	$ 24.26	$ 24.26
		Sub-Total Demolition	**$ 4,549.45**	**$ 1,302.36**

Maintenance	Costs / yr	Length Factor	EoL Yrs Maint	Life (yrs)	Adjusted Costs/ yr	Present Value Cost
Labor	$ 375.00	1.00	50.00	75	$ 375.00	8243
Equipment	$ 375.00	1.00	50.00	75	$ 375.00	8243
				Sub-Total Maintenance	**$ 750.00**	**$ 16,485.34**

Concrete Thornton Depot

Bridge Component:	Costs	Length Factor	Adjusted Costs	Present Value Cost
Prefabricated Bridge	$ 73,569.00	1.000	$ 73,569.00	$ 73,569.00
Labor	$ 11,800.00	1.000	$ 11,800.00	$ 11,800.00
Equipment	$ 10,444.00	1.000	$ 10,444.00	$ 10,444.00
Materials	$ 1,032.00	1.000	$ 1,032.00	$ 1,032.00
		Sub-Total Superstructure	**$ 96,845.00**	**$ 96,845.00**

Demolition	Costs	Length Factor	Adjusted Costs	Present Value Cost
Labor	$ 7,500.00	1.000	$ 7,500.00	$ 2,118.31
Equipment	$ 2,040.00	1.000	$ 2,040.00	$ 576.18
Salvage	$ 234.30	1.000	$ 234.30	$ 66.18
Landfill	$ 1,559.23	1.000	$ 1,559.23	$ 1,559.23
		Sub-Total Demolition	**$ 11,333.53**	**$ 4,319.90**

Maintenance	Costs / yr	Length Factor	EoL Yrs Maint	Life (yrs)	Adjusted Costs/ yr	Present Value Cost
Labor	$ 375.00	1.00	50.00	75	$ 375.00	$ 8,242.67
Equipment	$ 375.00	1.00	50.00	75	$ 375.00	$ 8,242.67
				Sub-Total Maintenance	**$ 750.00**	**$ 16,485.34**

Life Cycle Costs

Life Cycle Cost					
	Superstructure	Tot Initial	PV Maint	PV Demo	Total LCC
Steel	$ 57,324	$ 77,657	$ 16,485	$ 1,302	$ 95,445
Concrete	$ 73,569	$ 96,845	$ 16,485	$ 4,320	$ 117,650

Steel 78% 80% Same Less 81%

RESULTS – Steel Bridge Has Lower Initial & Life Cycle Costs

Considering Sustainability in Design Decisions

Monetizing Sustainability Benefits

- Sustainable design is predicated on the idea that society is willing to pay extra for reducing harmful effects on the environment.

  For these Two Bridges, This Decision is Trivial

  Steel has Higher Sustainability Benefits

  AND Steel has Lower Costs

  No Decision Required

  But, What if the Steel Bridge Cost More than the Concrete Bridge?

- Considering sustainability in the design of a bridge entails answering the question, “what additional cost would society or the owner be willing to pay to increase sustainability benefits?”

- Suppose Society is Willing to Pay:

  \$0.20 per kg of CO_2e Reduced

  \$0.04 per MJ of Energy Reduced

  \$50 per ton of Landfill Reduced

Considering Sustainability in Design Decisions

Monetizing Sustainability Benefits

- Then, an Equivalent Cost can be Determined for Any Number of Design Alternatives. Basis of Analysis on the Lowest Cost Alternative.

Equivalent Cost = [Initial or Life Cycle Cost]

- [Reduced kg CO_2e]*($0.20/kg CO_2e)

- [Reduced MJ]*($0.04/MJ)

- [Reduced Landfill tons]*($50/ton)

- The Lowest Equivalent Cost Alternative is Chosen Considering the Sustainability Benefits and Cost of the Alternative.
- This is Actually an Incremental Benefit-Cost Analysis “Hidden” in Terms Owners and Society Understand (Similar to Initial or Life Cycle Costs)

Considering Sustainability in Design Decisions

Equivalent Cost = [Initial or Life Cycle Cost] - [Reduced kg CO2e]*($0.20/kg CO2e) - [Reduced MJ]*($0.04/MJ) - [Reduced Landfill tons]*($50/ton)

Bridge	Initial or	Initial or Life Cycle Total			Reduction			Cost Benefit			Total Cost	**Equivalent Cost**
	Life Cycle Cost	kg CO2e	MJ Consumed	Landfill (tons)	kg CO2e	MJ Consumed	Landfill (tons)	kg CO2e	MJ Consumed	Landfill (tons)	Benefit	
Alt 1	$ 100,000	59726	725780	21	0	0	0	$0	$0	$0	$0	**$100,000**
Alt 2	$ 105,000	70000	720000	10	-10274	5780	11	-$2,055	$231	$540	-$1,284	**$106,284**
Alt 3	$ 105,000	47284	667459	1	12442	58321	20	$2,488	$2,333	$1,000	$5,821	**$99,179**
Alt 4	$ 107,000	45000	664000	10	14726	61780	11	$2,945	$2,471	$540	$5,956	**$101,044**
Alt 5	$ 107,000	44000	750000	1	15726	-24220	20	$3,145	-$969	$1,000	$3,176	**$103,824**

- Alt 1 is Lowest Initial Cost with a Basis Total Cost Benefit of Zero
- Alt 4 has highest Sustainability Benefits with $5956 more benefits than Alt 1, but Costs $7000 more than Alt 1 (Incremental B/C < 1) – the Sustainability Benefits are not Worth the Extra Cost
- Alt 3 has $5821 more Sustainability Benefits than Alt 1 and costs only $5000 more (Incremental B/C = 1.16) – the Sustainability Benefits Outweigh the Additional Costs
- Alts 2 & 4 additional sustainability benefits (if any) do not outweigh the additional costs
- Alt 3 costs $5000 more, but has a **Societal Accepted Rate of Return** of $5821
- This is Incremental Benefit Cost Analysis with Monetized Sustainability Benefits
- Owner or **Society Determines the Acceptable Cost for Sustainability Benefits**
- Owners Understand Equivalent Cost: Compare Similar to Initial Costs or Life Cycle Costs

Summary & Conclusions

Results of Steel Seltice-Warner and Concrete Thornton Depot Bridges

- Steel Shows Sustainability Benefits
- Steel Has Lower Initial and Life Cycle Costs

Equivalent Cost Procedure

- Similar to Initial Cost or Life Cycle Cost Decision Making
- Owner or Society Driven with Acceptable Sustainability Benefit Costs
- Flexible in Analysis Details

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

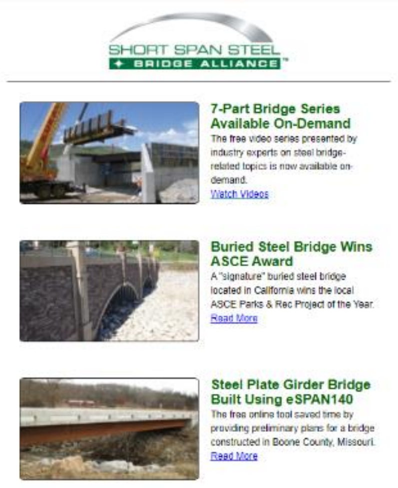
- Steel is North America's #1 Recycled Material – over 90% of steel in a beam is from recycled materials
- Recycled Steel Conserves Energy, enough to power 18 million homes
- Steel's Energy Use Reduced 33% Since 1990
- Greenhouse Gas Emissions Reduced by 45% since 1975

Resiliency

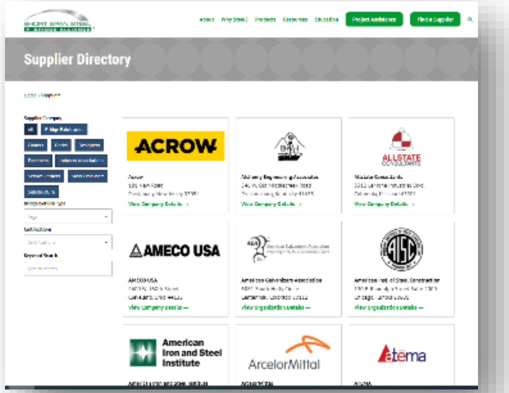
- Long Service Life
- Ease of Inspection
- Ease of Repair
- Strengthening for Increased Loads
- Recycling & Repurposing
- Habitat Protection

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

eSPAN140™

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

Tribal
Workshop: DIY ~~County~~ Bridges in 6 Steps

6-part Education to Potentially 3000 Counties on How They Can Build Their Own Bridges

Based on Whitman County, WA, Experience

2022 NACE

Invited Back for NACE 2023

Workshop Benefits

- Save Money and Build More Bridges!
- Workforce Development
- Minimize Public Inconvenience
- Accelerate Construction
- Use/Share County Equipment

Agenda (4 hours, including breaks)

- Module 1: Can My County Build This Bridge? (35 minutes)
- Module 2: Permits, Environmental Issues and Geotech Considerations (35 minutes)
- Module 3: Selecting Bridge Type and Bidding an Award (35 minutes)
- Module 4: Foundation and Substructure Design/Installation (35 minutes)
- Module 5: Installing the Bridge (35 minutes)
- Module 6: Commissioning and Opening to Traffic (35 minutes)

So You Want to Build a Bridge (and Save Money)?

DIY County Bridges in 6 Steps

SHORT SPAN STEEL BRIDGE ALLIANCE

Workshop Overview

Our nation is facing an infrastructure crisis. More than 220,000 bridges in the United States need major repair work or should be replaced. Nationwide, counties own and maintain 40 percent of the nation's bridges, making them the single largest stakeholder in local road and bridge construction, rehabilitation, expansion and maintenance.

This situation presents a significant challenge for cash-strapped state and local governments. To responsibly fix our nation's county bridges, cost-effective and sustainable solutions are needed – one option is to use county crews to assist with ... ed ... leo). ... structure ... steel ... fy the ... ected to develop the workshop, "So You Want to Build a Bridge? DIY County Bridges in 6 Steps."

"I think we can build a bridge for about half of what the contracting community can do."
Mark Storey, P.E.
Director/County Engineer
Whitman County, Washington Public Works

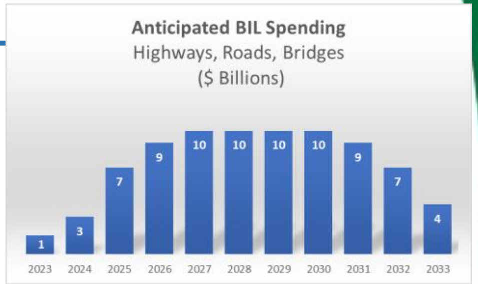
In the past 10 years, more than 15,000 bridge owners and designers have attended SSSBA workshops to learn about the cost and time advantages of short span steel bridges. Please join us for this entertaining and engaging educational adventure certain to save you time and money in future county bridge installations.

Whitman County Saved $30,000 by Building their Own Steel Bridge

Sample Video

https://www.shortspansteelbridges.org/county-saves-steel/

New Design-Build Bridge Bundling Case Study



Purpose – Help Owners Use Steel Bridges for Bundled Projects

Bipartisan Infrastructure Law

$39.5 billion over 5 years to repair or replace as many as 15,000 bridges

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

$200 million per year for Tribal Bridges – Bridge Bundling Important

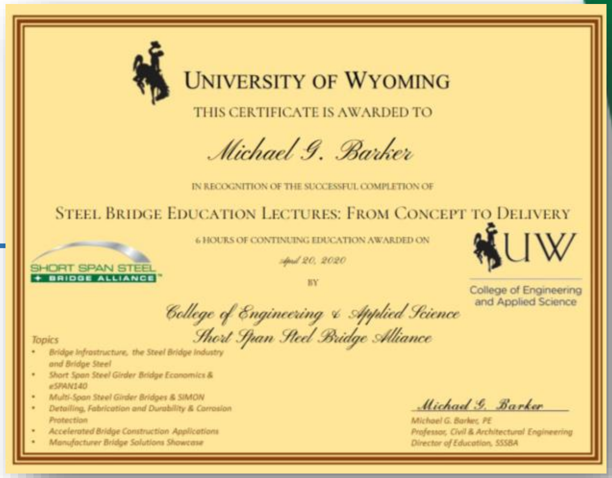
Based on Missouri DOT Fixing Access to Rural Missouri (FARM) Project

3 Bids – Steel Bridge Design Won

Interviews of:

MoDOT Bridge Engineer, Bryan Hartnagel
MoDOT Project Manager, Jeff Gander
Wilson Engineers Design Firm
Delongs Fabricator
Lehman Construction

Workshops: Online Education Packet



Getting Students, Faculty and Young Engineers Familiar with Steel Bridges and Instill a Positive Opinion of Steel Bridges is Imperative for the Future of Steel Bridges

9 Workshops Through 2022
Over 1400 Certificates Awarded
Upcoming Fall, 2023

Steel Bridge Education Lectures: From Concept to Delivery

Lecture 1: Bridge Infrastructure & the Steel Bridge Industry
Lecture 2: Short Span Steel Girder Economics & eSPAN140
Lecture 3: Multi-Span Steel Girder Bridges & SIMON
Lecture 4: Detailing, Fabrication and Durability & Corrosion Protection
Lecture 5: Accelerated Bridge Construction Applications
Lecture 6: Manufacturer Bridge Solutions Showcase

Next Early November, 7:00 Eastern Time
Invitation Soon

Register: www.shortspansteelbridges.org/

New 2024 Student Workshop: Simple Span Bridge Design

6-part steel bridge design education packet based on NSBA Navigating Routine Steel Bridge Design

Similar Online Certificate Program to Steel Bridges from Concept to Delivery

Target Audience:
University Students
Young Professionals

First Offering in 2024

80 ft Simple Span Plate Girder Design

Lecture 1: Introduction & Trial Bridge Design

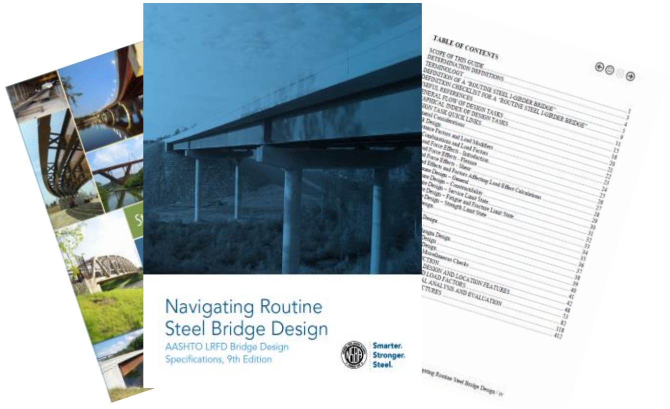
Lecture 2: Bridge Design

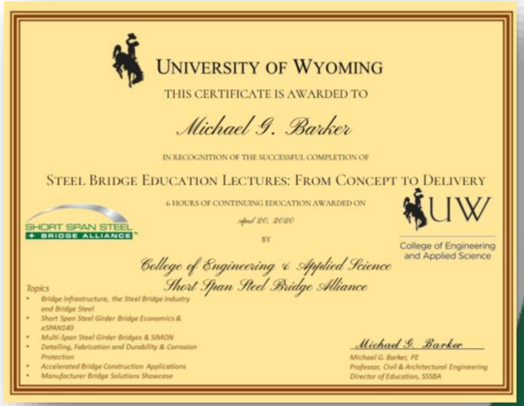
Lecture 3: Bridge Analysis & Design Limit States

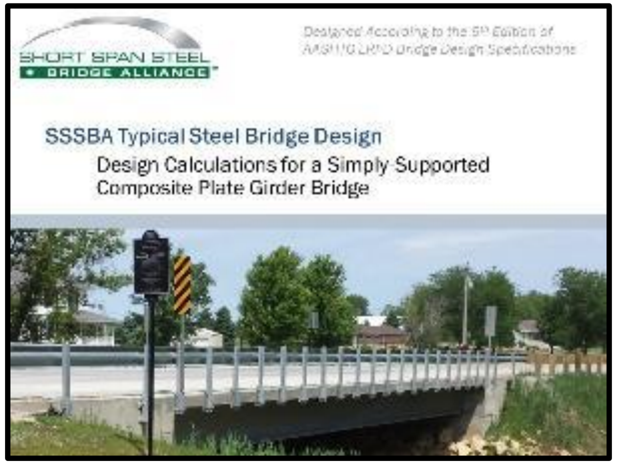
Lecture 4: Strength Design

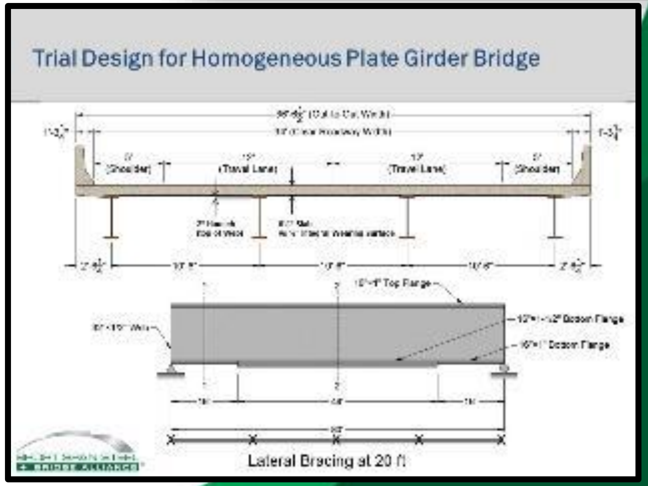
Lecture 5: Serviceability & Construction Design

Lecture 6: Detailing & Final Thoughts

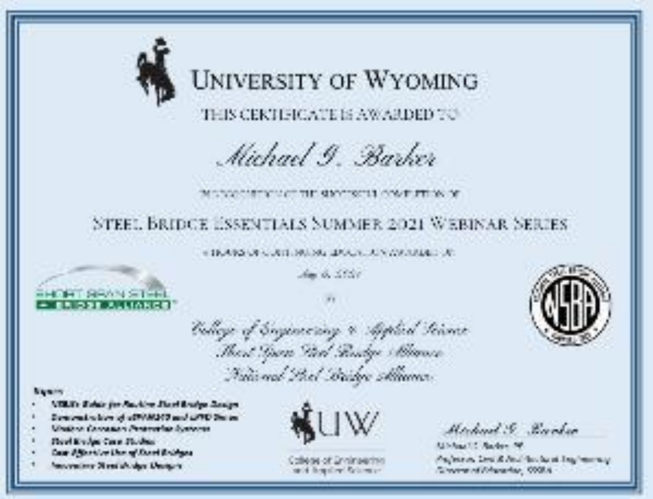








Summer On-Line Series: Professional



2020 Solutions for Cost-Effective Steel Bridges – Shelter-in-Place Summer Webinar Series
2021 Steel Bridge Essentials – 6-Part Summer Webinar Series
2022 Steel Bridge Essentials – Designing Cost-Effective & Resilient Bridges
2023 Steel Bridge 4-Part Webinar Series: Learning by Example

Wednesday, June 1 - Building a Sustainable Infrastructure with Steel Bridges
- Sustainability of the American Steel Industry
  - *Mark Thimons, Vice President, Sustainability, American Iron and Steel Institute*
- Sustainability of Rural Steel and Concrete Bridges
  - *Michael G. Barker, Ph.D., P.E., Professor, University of Wyoming*

Friday, June 3 - Modern Corrosion Protection Systems
- Durability Strategies for Steel Bridges
  - *Jeff Carlson, P.E., Director of Market Development, National Steel Bridge Alliance*
- Reference Manual for the Design, Detailing, and Maintenance of Uncoated Weathering Steel in Bridges
  - *Jennifer McConnell, Associate Professor, University of Delaware*
  - *Thomas Murphy, Ph.D., P.E., S.E., Modjeski and Masters, Inc.*

Monday, June 6 - Steel Bridge Case Studies
- Belmont Prefabricated Rolled-Beam Bridge
  - *Mark Storey, P.E., Public Works Director / County Engineer, Whitman County (WA)*
- TR-251 Press-Brake Tub Girder Bridge
  - *Jeff Blue, P.E., County Engineer, Champaign County (IL)*
- I-44 Bridge Replacements with Buried Bridges, Lawrence County, Missouri
  - *Joel Hahm, P.E., Senior Engineer, Contech Engineered Solutions LLC*
- Fixing Access to Rural Missouri (FARM) Bridge Program
  - *Gary W. Wisch, P.E., Vice President, Engineering, DeLong's, Inc*

Wednesday, June 8 – Steel Bridge Design Tools Demonstration
- Medium/Long Span Bridge Design Using LRFD Simon (165'-200'-165' span arrangement)
  - *Devin Altman, P.E., Bridge Steel Specialist, National Steel Bridge Alliance*
- Simple Span Bridge Design Using eSPAN140
  - *Gregory K. Michaelson, Ph.D., P.E., Associate Professor, Marshall University*

Friday, June 10 – Steel Bridge Economics
- Pricing Study of Recently Constructed Bridges
  - *John Hastings, P.E., Bridge Steel Specialist, Southeastern Market, National Steel Bridge Alliance*
- Historical Life Cycle Costs of Steel and Concrete Girder Bridges
  - *Michael G. Barker, Ph.D., P.E., Professor, University of Wyoming*

Workshops: Professional

Free Customized Workshops for Counties, DOTs, and Design Firms

Topics: Education, Events, Professional, Recommended

Short span bridges provide vital links in the nation's infrastructure network. Yet, nearly a quarter of these bridges are classified as structurally deficient or functionally obsolete.

According to ASCE, more than 30% of existing bridges have exceeded their 50-year design life. This situation presents a significant challenge for cash-strapped state and local governments.

The SSSBA has developed technological and design innovations for bridges under 140 feet that save significant time and costs for county and state bridge officials.

Over the past 10-years, over 5,000 bridge owners and designers have learned about the cost and time advantages of short span steel bridges in SSSBA workshops and conferences throughout North America.

And now, the SSSBA is offering **complimentary** customized educational guest speakers/webinars and workshops (on-site or virtual) specifically for county engineers, state DOTs, and design firms. The webinars/workshops are taught by industry experts with decades of experience in the cost-effective design and construction of short span bridges.

The workshops can be set up as:

- 1-2 hour webinar on a specific topic (can be used as a "guest speaker" for your event).

TRB Low Volume Roads Conference Summer 2023

Barron County, Wisconsin Fall 2023

SSSBA, This Morning, Sept 20, 2023

Hawaii DOT, November 2023

SHORT SPAN STEEL BRIDGE ALLIANCE

Short Span Steel Bridge Workshops

Over the past 10-years, over 5,000 bridge owners and designers have learned about the cost and time advantages of short span steel bridges in SSSBA workshops and conferences throughout North America.

And now, the SSSBA is offering **complimentary** customized educational workshops (on-site or virtual) specifically for county engineers, state DOTs, and design firms. The workshops are taught by industry experts with decades of experience in the cost-effective design and construction of short span bridges.

The workshops can be set up as:

- 1-2 hour webinar on a specific topic.
- 3-4 hour (half-day) workshop to provide practical information on the safe and cost-effective design, detail, fabrication and installation of short span steel bridges.
- 6 hours (full-day) session to provide an in-depth overview of short span steel bridges.

Suggested topics to select from include:

- Practical & Cost-Effective Steel Bridge Design
- Free Design Tools (eSPAN140 and SIMON)
- Pre-engineered Bridge Solutions
- Coating Solutions (galvanized, painted, and weathering steel)
- Accelerated Bridge Construction Options
- Case Studies (from local counties)
- Buried Soil Steel Bridge Structure Alternatives
- Life-Cycle Analysis

Sample Workshop Agenda (can also be altered for a virtual meeting)

<u>4-Hour Workshop Agenda</u>

00:00 (40 min) Introduction, Short Span Steel Bridge Overview & Design Tools (eSPAN140)
00:40 (35 min) Bridge Economy & Life Cycle Costs
01:15 (35 min) Steel Bridge Case Study
01:50 (25 min) Break (networking)
02:15 (35 min) National Steel Bridge Alliance Design Resources & SIMON (design software)
02:50 (35 min) Buried Steel Bridges Design & Construction
03:25 (35 min) Pre-Fabricated Steel Bridges & Accelerated Bridge Construction
04:00 Adjourn
** Each presentation will allow 5-10 minutes of Q&A*

<u>6-Hour Workshop Agenda</u>

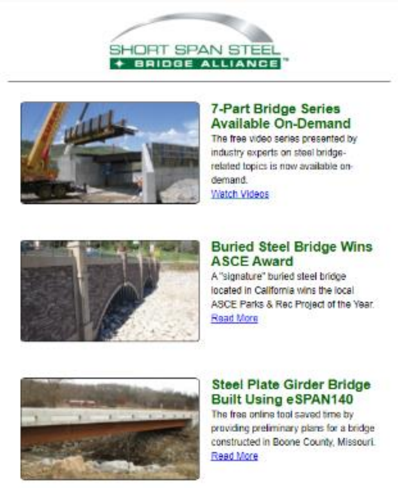
00:00 (45 min) Introduction, Short Span Steel Bridge Overview & Design Tools (eSPAN140)
00:45 (40 min) Bridge Economy & Life Cycle Costs
01:25 (35 min) Steel Bridge Case Study
02:00 (25 min) Break (networking)
02:25 (40 min) National Steel Bridge Alliance Design Resources & SIMON (design software)
03:05 (35 min) Practical Detailing, Durability and Steel Protection Systems
03:40 (40 min) Press-Brake Tub Girder Bridges
04:20 (25 min) Break (Lunch?)
04:45 (35 min) Buried Steel Bridges Design & Construction
05:20 (40 min) Pre-Fabricated Steel Bridges & Accelerated Bridge Construction
06:00 Adjourn
** Each presentation will allow 5-10 minutes of Q&A*

Contact Dan Snyder, Director of the SSSBA, for more information (dsnyder@steel.org – 301-367-6179)

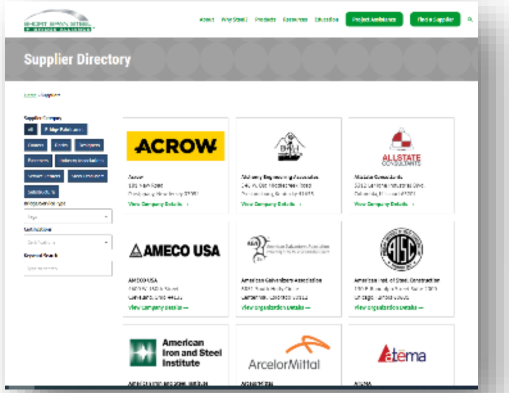
www.ShortSpanSteelBridges.org

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

eSPAN140™

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**