Optimized Simple Span Steel Bridge Design in Minutes: A Practical Design Tool for Engineers

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

Short Span Steel Bridge Alliance

*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**.*

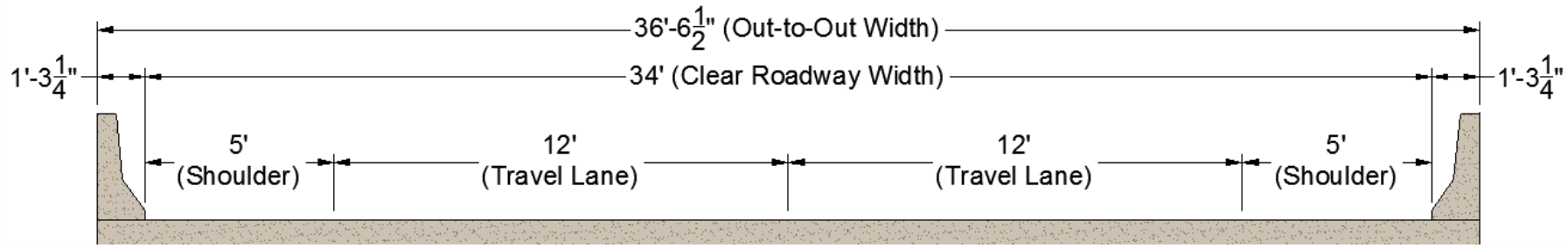
Myrissa Welch, SSAB, Chair SSSBA

Steel Bridge Design

Design Two-Lane, Simple Span Bridge

Bridge Need and Basic Information

- Decided by Owner/Engineer:
  - 80 ft Simple Span Composite – Steel Girders
  - Two 12 ft Travel Lanes, ADT = 5600 one direction
  - 34 ft Roadway Width
  - Jersey Barriers (1 ft – 3 ¼ in wide)



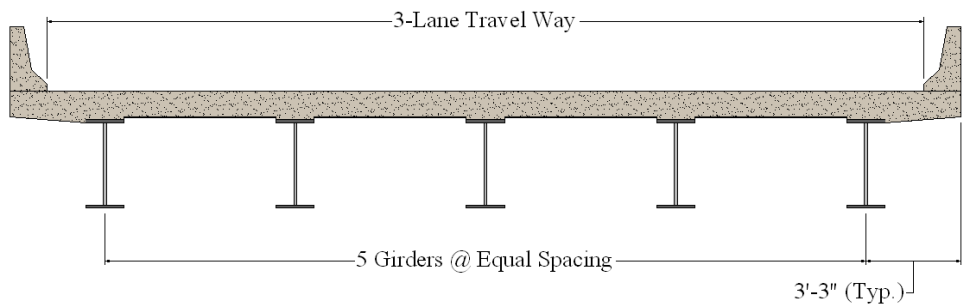
Need a Design for the Bridge SuperStructure

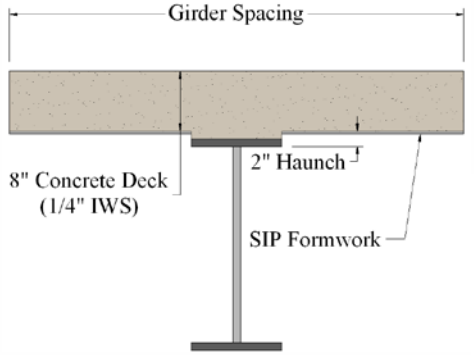
eSPAN140 - Standard Designs Short Span Bridges

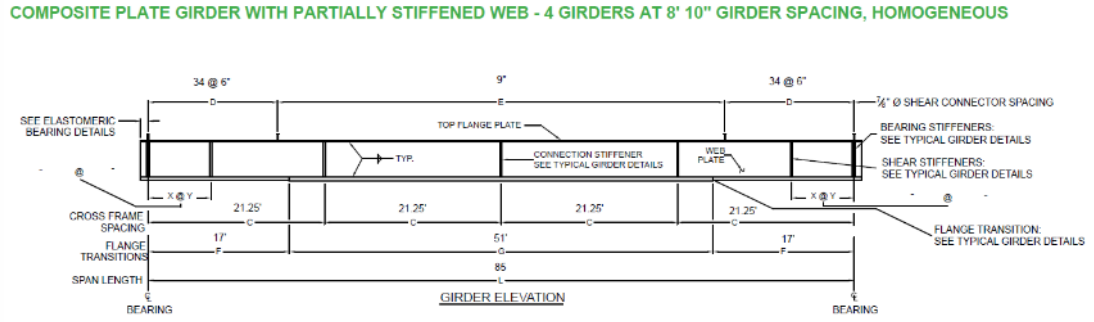
Span lengths 20 ft to 140 ft (in 5 ft increments)

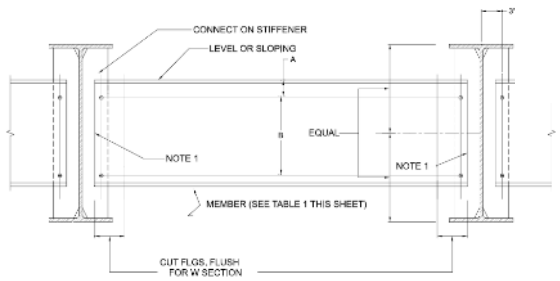
Four girder spacing: 6’-0”, 7’-6”, 9’-0” and 10’-6”,

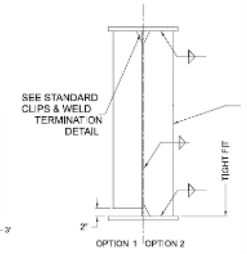
For each of these increments: Steel girders, Shear stud & stiffener layouts, Welding and fabrication details, Elastomeric bearings, and Concrete deck design





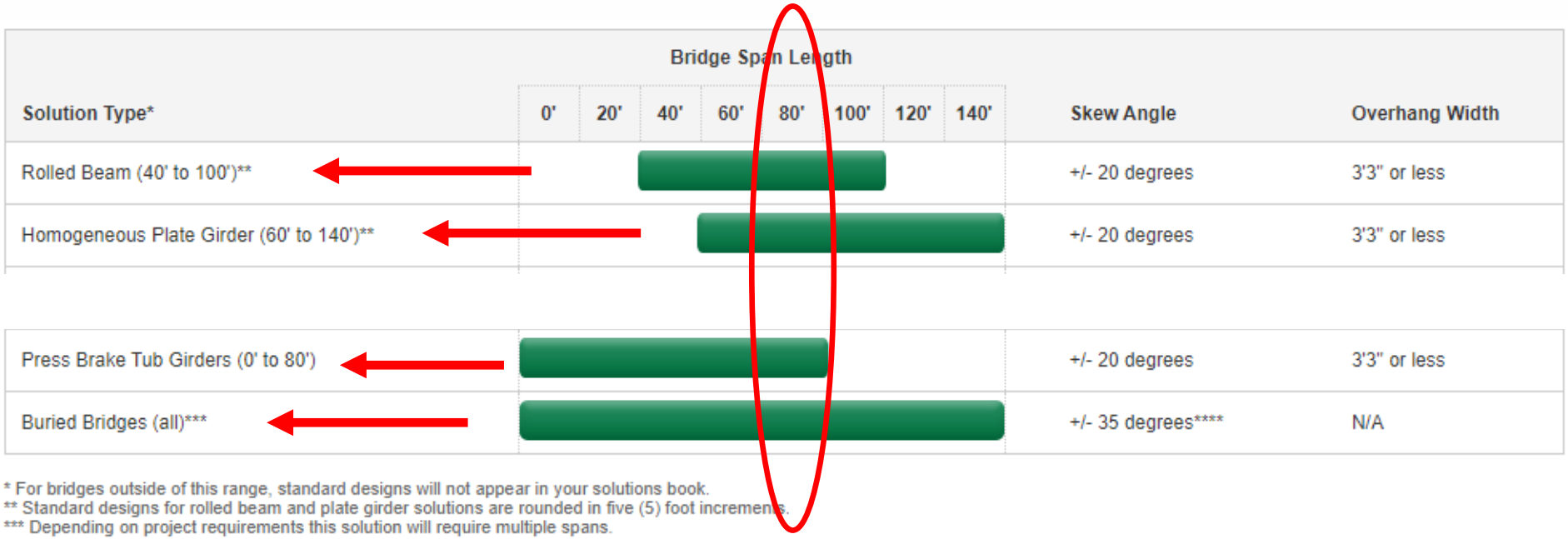






SHEAR STIFFENER
(N.T.S.)

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

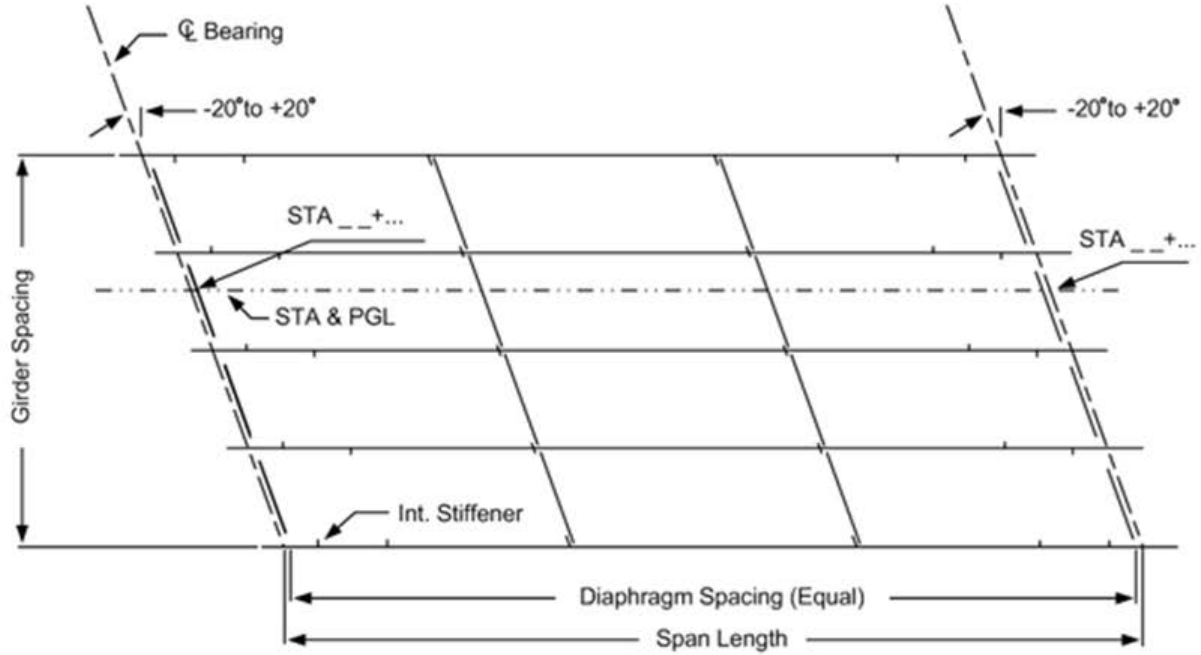
Roadway Name

E 800 South

Bridge Span Length*

80 *Feet* 0 *Inches*

Next > Return to Projects



Skew Angle (Overhead View)

eSPAN140 Preliminary Design

of Striped Traffic Lanes*
2

Roadway Width*
34 Feet
0 Inches

Individual Parapet Width
1 Feet
3.25 Inches

Individual Deck Overhang Width
2 Feet
6.25 Inches

Pedestrian Access?

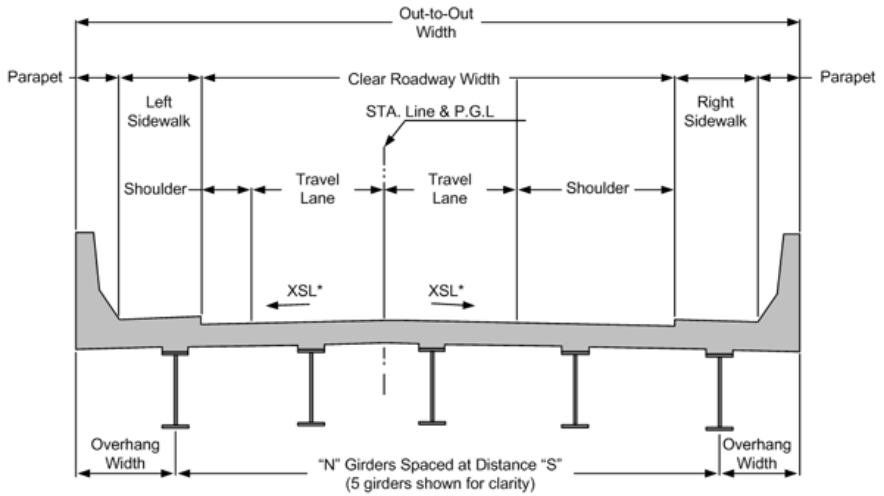
Skew Angle
0
Degrees

Average Daily Traffic
Over 2,000

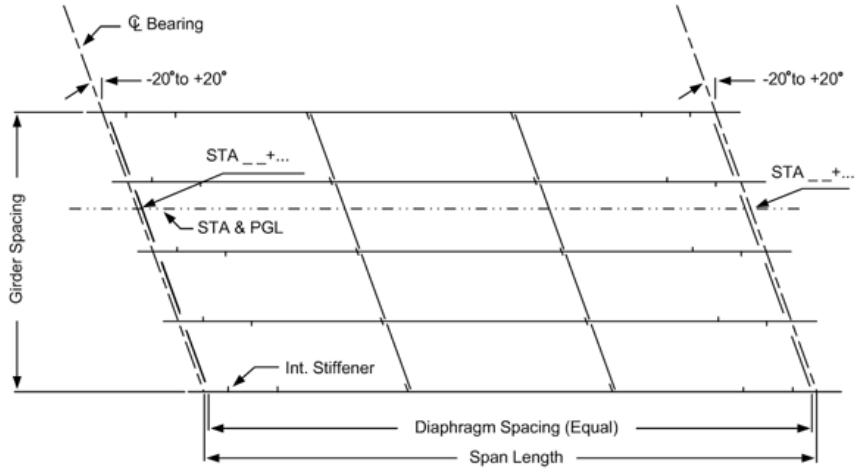
Design Speed
46+ mph

< Back | Next > | Return to Projects

* Required



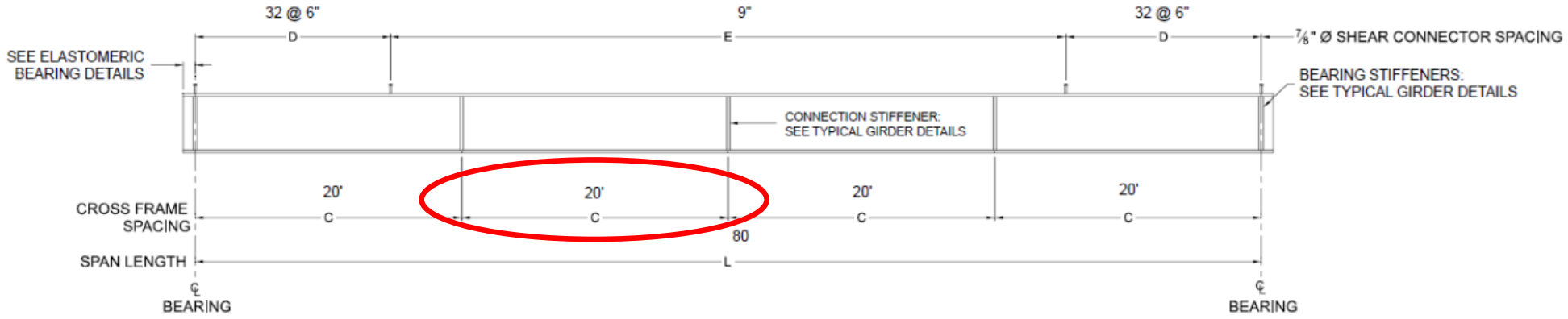
Cross-section of Bridge



Rolled Beam Recommendation

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

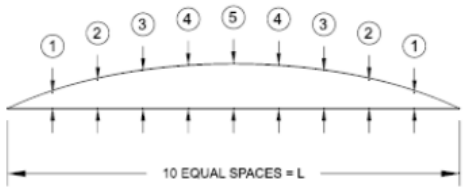
The selected rolled beam section is based on the widest (10'-6") girder spacing used in the development of the standards. The steel industry generally recommends the use of the widest girder spacing possible to reduce the potential number of girder lines for optimum economy.



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

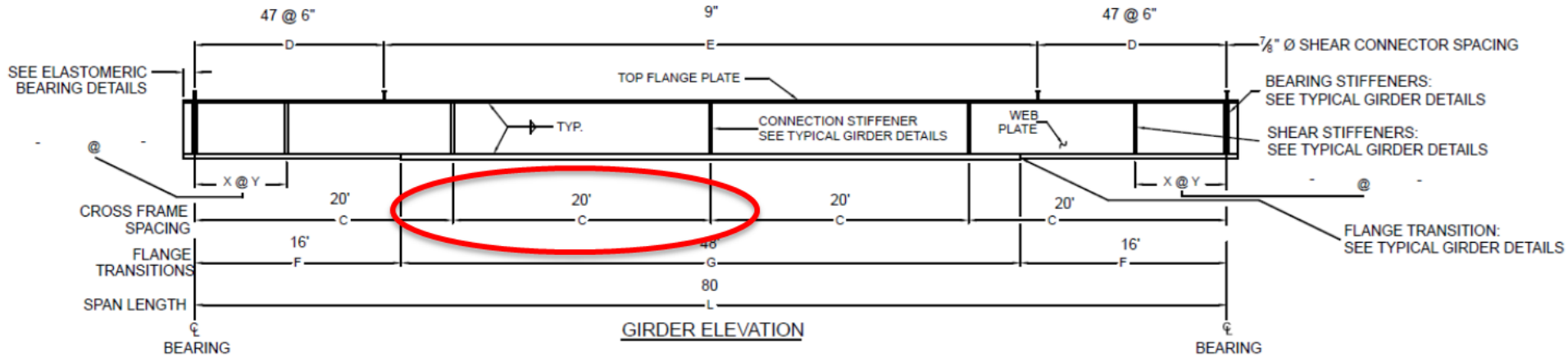
STEEL D.L. CAMBER - in					TOTAL D.L. CAMBER - in				
1	2	3	4	5	1	2	3	4	5
0.178"	0.337"	0.461"	0.540"	0.567"	1.255"	2.375"	3.250"	3.807"	3.997"



D.L. CAMBER

Plate Girder Recommendation

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



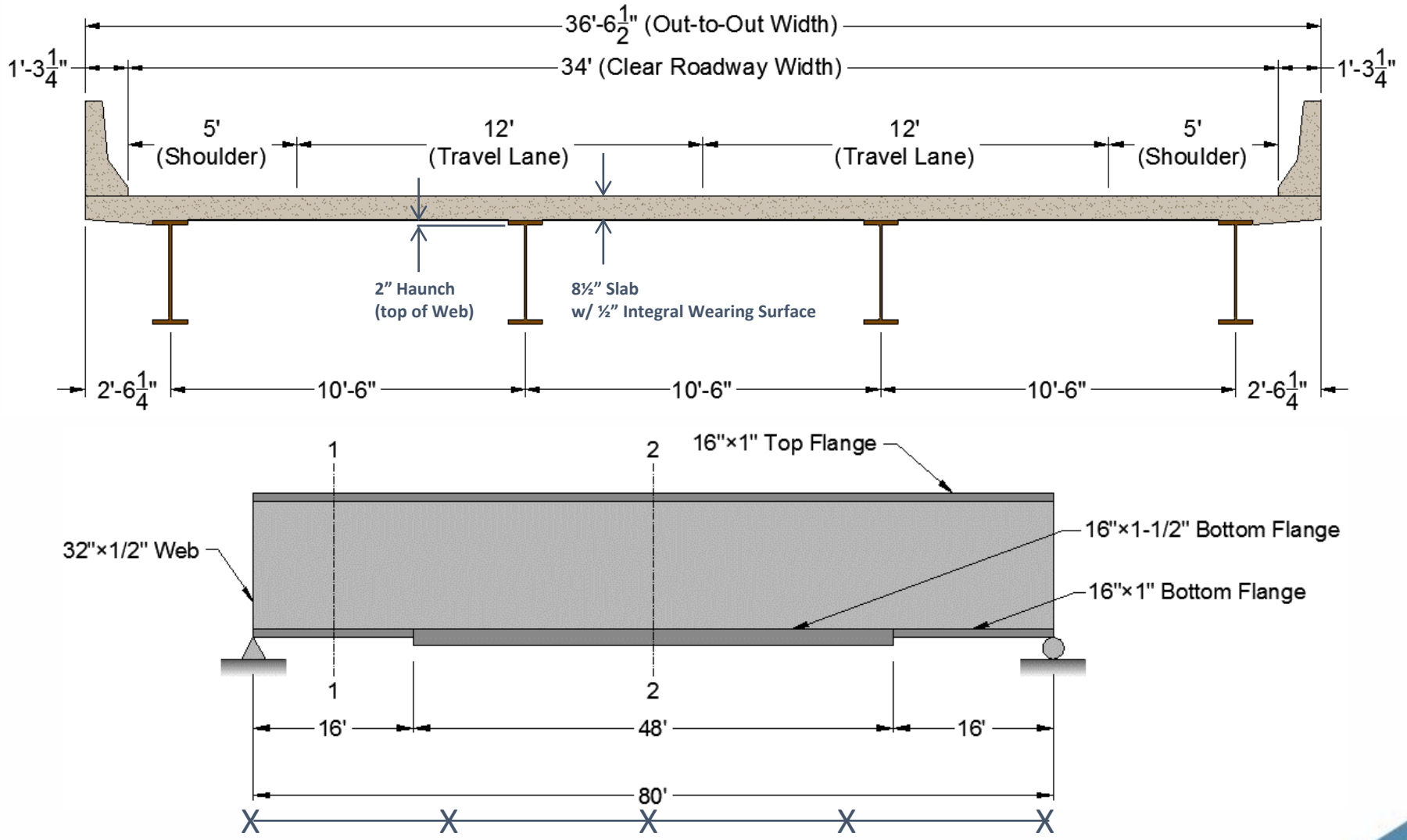
GIRDER ELEVATION

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"

D.L. CAMBER

Preliminary Design for Plate Girder Bridge



Diaphragms at 20 ft

eSPAN140 Summary

Composite Rolled Beam and Plate Girder Designs

1000's of Designs Performed

Has Worked Well

What's Next?

Update to AASHTO 10th Edition

Adding NonComposite Bridges

Including Additional Solution Options

Release TBD

NEW Short Span Steel Bridge Alliance eBEAM140

Noncomposite and Composite Simple-Span Rolled-Section Steel Bridge Design

Excel Based Rolled Beam Design Software

Version 1.0 - Beta

https://www.shortspansteelbridges.org/ebeam140/

eBEAM140 Disclaimer: *This document has been prepared in accordance with information available to the American Iron and Steel Institute (AISI) and its Short Span Steel Bridge Alliance (SSSBA) program, at the time of preparation. While it is believed to reasonably reflect the present state of knowledge as to the subject, it has not been prepared for conventional use as an engineering or construction document and should not be used or relied upon for any specific application without competent professional examination and verification of its accuracy, suitability, and applicability by a licensed engineer, architect or other professional. AISI and the SSSBA disclaim any liability arising from information provided by others or from the unauthorized use of the information contained in this document, and do not accept any obligation to issue supplements or corrections in the event of errors being discovered or advances being made in the techniques discussed in the document.*

Start With Demonstration

NonComposite Bridge

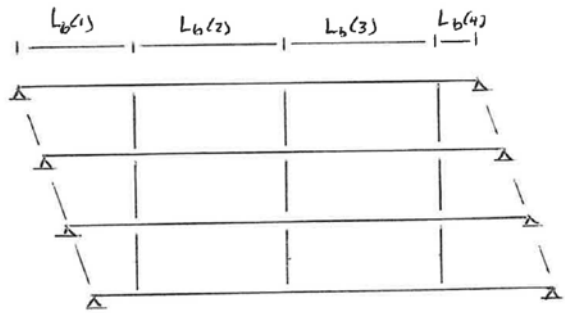
- **52 ft Length**
- **Two 12 ft Lanes**
- **6 Girders at 5’-6” Spacing**
- Overhang 1’ – 3”
- Barriers 1’ – 0” (50 lb/ft – 50% on Exterior Girder)
- Roadway Width = 28 ft (4 ft of shoulder)
- Bridge Width 30 ft
- **Diaphragm (Centerline) at 26 ft**
- **Unbraced**
- **Corrugated Metal Deck & Gravel (80 psf)**
- No Additional DC1 or DC2 Loading
- No Wearing Surface
- No Construction Load (No Lateral Flange)
- Misc Steel of 5%
- 50 ksi Steel, L/D limit 30, Min d = 12
- L/800 Deflection Limit
- Compression Flange not Braced
- Use AASHTO Appendix A6
- 75 Year Design Life & $ADTT_{SL}$ = 200
  - Fatigue II – Finite Life
- No User Defined Vehicle

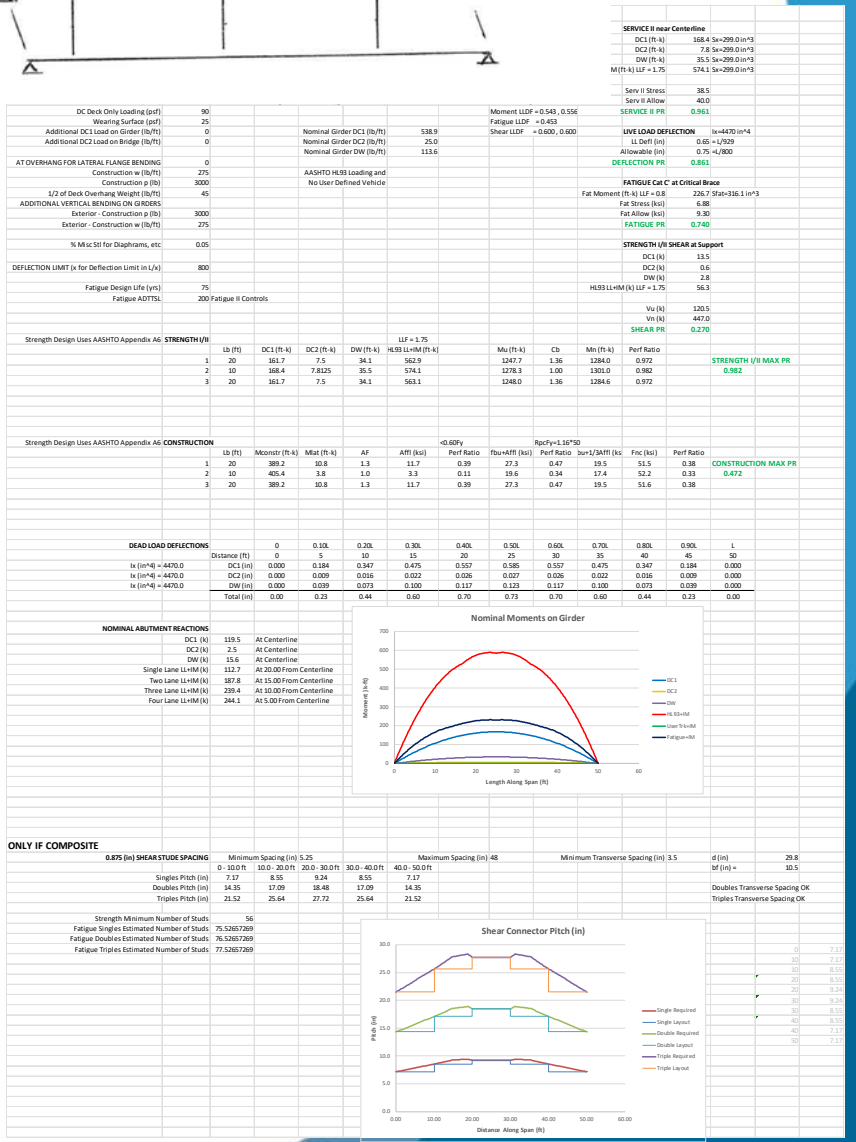
W36x135 Strength I PR = 0.993

Design Software

Excel Based Rolled Beam Design Software

- NonComposite & Composite Design
- 33, 36, 50, 65 or 70 ksi Steel
- Bridge Layout
- Diaphragm Variable Along Span
- Any Decking: Wood, Grid, CMD, Noncomposite Concrete, Composite Concrete
- Vehicular Loading: AASHTO HL93 & User Defined Vehicle (i.e., U-80)





Design Software

Excel Based Rolled Beam Design Software

- Diaphragm Variable Along Span: up to 7 Unbraced Lengths: Skewed Bridges
  - Compression Flange Bracing During Construction
  - Compression Flange Bracing for Final State
- Any Decking: Wood, Grid, CMD, Noncomposite Concrete, Composite Concrete
  - For Composite: f'c, full depth or SIP, haunch, sacrificial surface, shear connector design
  - Additional Dead Load (DC1 – Overhang, Utilities, etc)
  - Variable Bridge Railing
  - Steel Beams Individually Considered in Dead Load
- Wearing Surface
- Additional Dead Load (DC2 – Utilities, etc)

Design Software

Excel Based Rolled Beam Design Software

- Vehicular Loading
  - AASHTO HL93 truck, Tandem and Lane
  - User Defined Vehicle (i.e., U-80)
    - User Live Load Factor (Strength II)
    - Optional Lane Load
    - Single or Multi-Lane Distribution
    - User Impact Factor
- Live Load Distribution Factors
  - Moment & Shear (Based on Decking)
  - Lever Rule if Necessary
  - Single & Multi-Lane
  - Rigid Rotational Analysis
  - User Input LLDF

Design Software

Excel Based Rolled Beam Design Software

- Limit L/D Ratio
- Minimum Depth (diaphragms)
- Maximum Depth (approaches/clearance)
- Option on W40/44
- User Defined Deflection Limit
- Add % Steel for Miscellaneous
- Applies AASHTO 6.10.8 (conservative) or Appendix A6 (optimal) - AASHTO 10
- Calculated Cb for Each Unbraced Length - AASHTO 10
  - User defined Cb

Design Software

Excel Based Rolled Beam Design Software

- Fatigue I or Fatigue II Based on $ADTT_{SL}$ – AASHTO 10
  - Variable Design Life
- Performs Dead, Construction & Live Load Analysis for Each Unbraced Length
- Strength I/II & Constructability Design for Each Unbraced Length
- Service II Near Centerline (Maximum Moment)
- Fatigue at Critical Diaphragm Location (Detail C')
- Strength & Fatigue Shear Stud Design for Composite – AASHTO 10

Design Software

Excel Based Non-Composite Rolled Beam Design Software

- Determines all W Shapes that Meet Strength I/II, Service II & Construction Performance Ratios
- Corresponding Fatigue Performance Ratio
- Corresponding Deflection Performance Ratio

Lightest 10 Sections (see to the right for additional Information)						
Str I, Serv II, Constr	Fatigue	Deflection	L/D	Defl	Mn/My	Weight (tons)
W36X135	W36X135	W36X135	17.5	L/1049	0.78	21.1
W33X141	W33X141	W33X141	18.7	L/1002	0.82	22.0
W27X146	W27X146		22.8	L/761	1.03	22.8
W30X148	W30X148	W30X148	20.3	L/898	0.82	23.1
W40X149	W40X149	W40X149	16.3	L/1317	0.74	23.2
W36X150	W36X150	W36X150	17.4	L/1215	0.84	23.4
W33X152	W33X152	W33X152	18.6	L/1097	0.86	23.7
W36X160	W36X160	W36X160	17.3	L/1312	0.87	25.0
W27X161	W27X161	W27X161	22.6	L/848	1.05	25.1
W24X162	W24X162		25.0	L/695	1.07	25.3

Design Software

Excel Based Rolled Beam Design Software

- Allows User to Investigate Alternatives to
  - Diaphragm Spacing
  - Lightest Weight Solution
  - Other Readily Available Sections

ENTER W SECTION FOR MORE INFORMATION — Weight (lb/ft)

W36X135 — **NonComposite** — 135

OVERALL PERFORMANCE FOR W36X135

Strength I/II	Service II	Construction	Fatigue	Deflection		Overall
PR	PR	PR	PR	PR		PR
0.993	0.727	0.161	0.599	0.763		0.993
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to		Strength I/II
1		1		L/1049		

PERFORMANCE BY UNBRACED LENGTH FOR W36X135

			Strength I/II		
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb
1	26	0 - 26 ft	0.993	0.778	1.255
2	26	26 - 52 ft	0.993	0.778	1.256

LIST OF ALL W SHAPES RANKED FROM STRENGTH I, SERVICE II & CONSTRUCTION

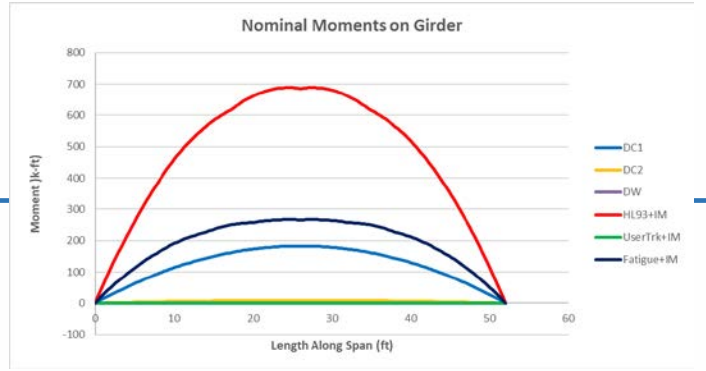
Top 20 That Meet Min Depth, Max Depth & W40 & W44 Limits

Shape	Strength I/II	Service II	Construction	Fatigue	Deflection	Overall
	PR	PR	PR	PR	PR	PR
W36X135	**0.99**	**0.73**	**0.16**	0.60	0.76	0.99
W33X141	**0.92**	**0.71**	**0.15**	0.58	0.80	0.92
W27X146	**0.79**	**0.77**	**0.14**	0.62	1.05	1.05
W30X148	**0.95**	**0.73**	**0.16**	0.58	0.89	0.95
W40X149	**0.90**	**0.62**	**0.15**	0.51	0.61	0.90
W36X150	**0.81**	**0.64**	**0.13**	0.52	0.66	0.81
W33X152	**0.81**	**0.66**	**0.14**	0.53	0.73	0.81
W36X160	**0.73**	**0.59**	**0.12**	0.48	0.61	0.73
W27X161	**0.71**	**0.70**	**0.13**	0.55	0.94	0.94
W24X162	**0.77**	**0.78**	**0.14**	0.60	1.15	1.15
W40X167	**0.70**	**0.54**	**0.12**	0.43	0.51	0.70
W33X169	**0.69**	**0.59**	**0.12**	0.46	0.64	0.69
W36X170	**0.66**	**0.56**	**0.11**	0.44	0.57	0.66
W30X173	**0.59**	**0.60**	**0.11**	0.47	0.72	0.72
W24X176	**0.70**	**0.72**	**0.13**	0.54	1.05	1.05
W27X178	**0.63**	**0.64**	**0.12**	0.50	0.85	0.85
W36X182	**0.61**	**0.52**	**0.11**	0.41	0.53	0.61
W40X183	**0.59**	**0.48**	**0.10**	0.38	0.45	0.59
W30X191	**0.53**	**0.54**	**0.10**	0.42	0.65	0.65
W24X192	**0.63**	**0.66**	**0.12**	0.50	0.95	0.95

Design Software

Excel Based Rolled Beam Design Software

- Design Summary
  - All Superstructure Design Results Specific to Limit States, Unbraced Lengths, etc.
  - Dead Load Deflections for Camber
  - Abutment Reaction Cases for Multi-Lane
  - If Composite: Strength and Fatigue Stud Design



W44	**SERVICE II near Centerline**		
	DC1 (ft-k)	183.1	Sx=439.0 in^3
	DC2 (ft-k)	8.5	Sx=439.0 in^3
	DW (ft-k)	0.0	Sx=439.0 in^3
	HL93 LL+IM (ft-k)	670.5	Sx=439.0 in^3
	Serv II Stress	29.1	
Lane	Serv II Allow	40.0	
	SERVICE II PR	**0.727**	
	LIVE LOAD DEFLECTION		Ix=7800 in^4
	LL Defl (in)	0.60	= L/1049
	Allowable (in)	0.78	=L/800
	DEFLECTION PR	**0.763**	
	FATIGUE Cat C' at Critical Brace		
Fat Moment (ft-k) LLF = 0.8		265.8	Sfat=458.6 in^3
	Fat Stress (ksi)	5.57	
	Fat Allow (ksi)	9.30	
	FATIGUE PR	**0.599**	
	STRENGTH I/II SHEAR at Support		
	DC1 (k)	14.1	
	DC2 (k)	0.7	
	DW (k)	0.0	
HL93 LL+IM (k) LLF = 1.75		60.6	
	Vu (k)	124.5	
	Vn (k)	591.9	
	SHEAR PR	**0.210**	

Strength Design Uses AASHTO Appendix A6	**STRENGTH I/II**					LLF = 1.75							
		Lb (ft)	DC1 (ft-k)	DC2 (ft-k)	DW (ft-k)	HL93 LL+IM (ft-k)		Mu (ft-k)	Cb	Mn (ft-k)	Perf Ratio		
	1	26	183.1	8.45	0.0	670.4		1412.6	1.26	1422.9	0.993		**STRENGTH I/II MAX PR**
	2	26	183.1	8.45	0.0	670.5		1412.9	1.26	1423.3	0.993		**0.993**

Strength Design Uses AASHTO Appendix A6	**CONSTRUCTION**						<0.60Fy		RpcFy=1.16*50				
		Lb (ft)	Mconstr (ft-k)	Mlat (ft-k)	AF	Affl (ksi)	Perf Ratio	fbu+Affl (ksi)	Perf Ratio	bu+1/3Affl (ks	Fnc (ksi)	Perf Ratio	
	1	26	228.9	0.0	1.0	0.0	0.00	6.3	0.13	6.3	38.9	0.16	**CONSTRUCTION MAX PR**
	2	26	228.9	0.0	1.0	0.0	0.00	6.3	0.13	6.3	38.9	0.16	**0.161**

NOMINAL ABUTMENT REACTIONS			
DC1 (k)	84.5	At Centerline	
DC2 (k)	2.6	At Centerline	
DW (k)	0.0	At Centerline	
Single Lane LL+IM (k)	114.3	At 9.00 From Centerline	
Two Lane LL+IM (k)	190.4	At 4.00 From Centerline	

Modify Demonstration

NonComposite Bridge

- 52 ft Length
- Two 12 ft Lanes
- 6 Girders at 5’-6” Spacing
- Overhang 1’ – 3”
- Barriers 1’ – 0” (50 lb/ft – 50% on Exterior Girder)
- Roadway Width = 28 ft (4 ft of shoulder)
- Bridge Width 30 ft
- Diaphragm (Centerline) at 26 ft
- Unbraced
- Corrugated Metal Deck & Gravel (80 psf)
- No Additional DC1 or DC2 Loading
- No Wearing Surface
- No Construction Load (No Lateral Flange)
- Misc Steel of 5%
- 50 ksi Steel, L/D limit 30, Min d = 12
- L/800 Deflection Limit
- Compression Flange not Braced
- Use AASHTO Appendix A6
- 75 Year Design Life & $ADTT_{SL}$ = 200
  - Fatigue II – Finite Life
- No User Defined Vehicle

W36x135 Strength I PR = 0.993

Demonstration: 52 ft Span, CMD/Gravel, 6 Girders @ 5.5 ft

NonComposite Bridge: W36 x 135

- What if add additional diaphragm: L_b = 19, 14, 19 ft

ENTER W SECTION FOR MORE INFORMATION					Weight (lb/ft)	
W36X135		NonComposite			135	
	OVERALL PERFORMANCE FOR W36X135					
Strength I/II	Service II	Construction	Fatigue	Deflection		Overall
PR	PR	PR	PR	PR		PR
0.993	0.727	0.161	0.599	0.763		0.993
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to		Strength I/II
1		1		L/1049		
PERFORMANCE BY UNBRACED LENGTH FOR W36X135						
			Strength I/II			
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb	
1	26	0 - 26 ft	0.993	0.778	1.255	
2	26	26 - 52 ft	0.993	0.778	1.256	

ENTER W SECTION FOR MORE INFORMATION					Weight (lb/ft)	
W33X118		NonComposite			118	
	OVERALL PERFORMANCE FOR W33X118					
Strength I/II	Service II	Construction	Fatigue	Deflection		Overall
PR	PR	PR	PR	PR		PR
0.981	0.883	0.155	0.703	1.009		1.009
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to		Deflection
2		2		L/793		
PERFORMANCE BY UNBRACED LENGTH FOR W33X118						
			Strength I/II			
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb	
1	19	0 - 19 ft	0.781	1.139	1.391	
2	14	19 - 33 ft	0.981	0.957	1.005	
3	19	33 - 52 ft	0.781	1.140	1.392	

W33x118 – 5400 lbs Girder Steel Saved
But Additional Diaphragm
And Deflection = L/793

Demonstration: 52 ft Span, CMD/Gravel, 6 Girders @ 5.5 ft

NonComposite Bridge: W36 x 135

- What if compression flange braced: Lb = 0 Corrugated Metal Decking

ENTER W SECTION FOR MORE INFORMATION					Weight (lb/ft)	
W36X135		NonComposite			135	
	OVERALL PERFORMANCE FOR W36X135					
Strength I/II	Service II	Construction	Fatigue	Deflection		Overall
PR	PR	PR	PR	PR		PR
0.993	0.727	0.161	0.599	0.763		0.993
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to		Strength I/II
1		1		L/1049		
PERFORMANCE BY UNBRACED LENGTH FOR W36X135						
			Strength I/II			
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb	
1	26	0 - 26 ft	0.993	0.778	1.255	
2	26	26 - 52 ft	0.993	0.778	1.256	

ENTER W SECTION FOR MORE INFORMATION					Weight (lb/ft)	
W30X116		NonComposite			116	
	OVERALL PERFORMANCE FOR W30X116					
Strength I/II	Service II	Construction	Fatigue	Deflection		Overall
PR	PR	PR	PR	PR		PR
0.892	0.963	0.161	0.788	1.207		1.207
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to		Deflection
2		1		L/663		
PERFORMANCE BY UNBRACED LENGTH FOR W30X116						
Compression Flange Laterally Braced for Final State			Strength I/II			
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb	
1	26	0 - 26 ft	0.892	1.149	1.255	
2	26	26 - 52 ft	0.892	1.149	1.256	

W30x116 – 6000 lbs Girder Steel Saved
But Deflection = L/663

Demonstration: 52 ft Span, CMD/Gravel, 6 Girders @ 5.5 ft

NonComposite Bridge: W36 x 135

- What if Logging Truck User Vehicle: 160 kips, 5 Axles

ENTER W SECTION FOR MORE INFORMATION					Weight (lb/ft)	
W36X135		NonComposite			135	
	OVERALL PERFORMANCE FOR W36X135					
Strength I/II	Service II	Construction	Fatigue	Deflection		Overall
PR	PR	PR	PR	PR		PR
0.993	0.727	0.161	0.599	0.763		0.993
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to		Strength I/II
1		1		L/1049		
PERFORMANCE BY UNBRACED LENGTH FOR W36X135						
			Strength I/II			
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb	
1	26	0 - 26 ft	0.993	0.778	1.255	
2	26	26 - 52 ft	0.993	0.778	1.256	

ENTER W SECTION FOR MORE INFORMATION						Weight (lb/ft)	
W36X150			NonComposite			150	
		OVERALL PERFORMANCE FOR W36X150					
Strength I/II	Service II	Construction	Fatigue	Deflection			Overall
PR	PR	PR	PR	PR			PR
0.937	0.736	0.134	0.516	0.658			0.937
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to			Strength I/II
1		1		L/1215			
PERFORMANCE BY UNBRACED LENGTH FOR W36X150							
			Strength I/II				
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb		
1	26	0 - 26 ft	0.937	0.837	1.255		
2	26	26 - 52 ft	0.937	0.837	1.256		

Strength II: LLF = 1.35, No Lane Load, Single Lane, Unbraced W36x150

Strength II: LLF = 1.35, No Lane Load, Single Lane, Braced W33x130

Another Demonstration

Composite Bridge

- **62 ft Length**
- **Two 12 ft Lanes**
- **4 Girders at 9’-0” Spacing**
- Overhang 2’ – 0”
- Barriers 1’ – 6” (250 lb/ft – 50% on Exterior Girder)
- Roadway Width = 28 ft (4 ft of shoulder)
- Bridge Width 31 ft
- Diaphragms at 21 ft & 41 ft
- 8” Structural Deck, ½” Sacrificial, 2” Haunch
- 2” Stay-in-Place Forms (15 psf)
- 7/8” Shear Studs; f'_c = 4000 psi
- Additional DC1 Loading = 40 lb/ft
  - 100% on Girder
- 25 lb/ft^2 Wearing Surface
- Construction Load (w = 275 lb/ft & p = 3000 lb)
- Misc Steel of 5%
- 50 ksi Steel, L/D limit 30, Min d = 12
- L/800 Deflection Limit
- Compression Flange not Braced - Construction
- Use AASHTO Appendix A6
- 75 Year Design Life & $ADTT_{SL}$ = 1000
  - Fatigue I – Infinite Life
- No User Defined Vehicle

W36x135 Fatigue PR = 0.961

Demonstration: 62 ft Span, 8” Deck w/SIP, 4 Girders @ 9 ft

Composite Bridge

Lightest 10 Sections (see to the right for additional Information)						
Str I, Serv II, Constr	Fatigue	Deflection	L/D	Defl	Mn/My	Weight (tons)
W36X135	W36X135	W36X135	20.9	L/1295	1.88	16.7
W33X141	W33X141	W33X141	22.3	L/1204	1.78	17.5
W27X146			27.2	L/927	1.66	18.1
W40X149	W40X149	W40X149	19.5	L/1553	1.82	18.5
W36X150	W36X150	W36X150	20.7	L/1421	1.78	18.6
W33X152	W33X152	W33X152	22.2	L/1281	1.75	18.8
W36X160	W36X160	W36X160	20.7	L/1491	1.74	19.8
W27X161	W27X161	W27X161	27.0	L/998	1.62	20.0
W24X162			29.8	L/846	1.64	20.1
W40X167	W40X167	W40X167	19.3	L/1726	1.72	20.7

ENTER W SECTION FOR MORE INFORMATION					Weight (lb/ft)	
W36X135		Composite			135	
	OVERALL PERFORMANCE FOR W36X135					
Strength I/II	Service II	Construction	Fatigue	Deflection		Overall
PR	PR	PR	PR	PR		PR
0.793	0.876	0.947	0.961	0.618		0.961
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to		Fatigue
2		2		L/1295		
ERFORMANCE BY UNBRACED LENGTH FOR W36X135						
			Strength I/II			
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb	
1	21	0 - 21 ft	0.721	1.883	1.425	
2	20	21 - 41 ft	0.793	1.883	1.009	
3	21	41 - 62 ft	0.721	1.883	1.425	

W36x135 Fatigue PR = 0.961

Demonstration: 62 ft Span, 8” Deck w/SIP, 4 Girders @ 9 ft

Composite Bridge

W36X135	**Composite**				Consider W40 & W44 Beams?	Yes		Minimum Depth Beam	W12					
Overall PR = 0.961 - Fatigue					L/D Limited to	25		Maximum Depth Beam	W44		**SERVICE II near Centerline**			
Yield Strength (ksi)	50										DC1 (ft-k)	492.3	Sx=439.0 in^3	
Bridge Length (ft)	62			Bridge Width (ft)	31.00						DC2 (ft-k)	60.1	S3n=600.0 in^3	
Girder Spacing (ft)	9			Roadway Width (ft)	28.00						DW (ft-k)	84.1	S3n=600.0 in^3	
Number of Girders	4		Shoulders (ft) each side - Double for One Sided		2.00						HL93 LL+IM (ft-k)	1093.4	Sn=675.0 in^3	
Overhang (22.2% of Girder Spacing) (ft)	2		2 Striped Lanes and 2 Design Lanes											
Barrier Width (ft)	1.5							Lateral Distribution Factors			Serv II Stress	41.6		
Barrier Load on Girder (lb/ft)	125		8 in Structural Deck with 2 in SIP Forms					Single Lane/Multi-Lane			Serv II Allow	47.5		
DC Deck Only Loading (psf)	106.25			Deck f'c (psi)	4000			Moment LLDF = 0.660 , 0.767			**SERVICE II PR**	**0.876**		
Wearing Surface (psf)	25			Haunch from Top of Web (in)	2			Fatigue LLDF = 0.550						
Additional DC1 Load on Girder (lb/ft)	40			Nominal Girder DC1 (lb/ft)	1024.6			Shear LLDF = 0.720 , 0.884			**LIVE LOAD DEFLECTION**		In=21650.2 in^4	
Additional DC2 Load on Bridge (lb/ft)	0			Nominal Girder DC2 (lb/ft)	125.0						LL Defl (in)	0.57	= L/1295	
				Nominal Girder DW (lb/ft)	175.0						Allowable (in)	0.93	=L/800	
AT OVERHANG FOR LATERAL FLANGE BENDING	0										**DEFLECTION PR**	**0.618**		
Construction w (lb/ft)	275			AASHTO HL93 Loading and										
Construction p (lb)	3000			No User Defined Vehicle							**FATIGUE Cat C' at Critical Brace**			
1/2 of Deck Overhang Weight (lb/ft)	108.75										Fat Moment (ft-k) LLF = 1.75	380.0	Sfat=692.0 in^3	
ADDITIONAL VERTICAL BENDING ON GIRDERS											Fat Stress (ksi)	11.53		
Exterior - Construction p (lb)	3000										Fat Allow (ksi)	12.00		
Exterior - Construction w (lb/ft)	275										**FATIGUE PR**	**0.961**		
% Misc Stl for Diaphrams, etc	5%										**STRENGTH I/II SHEAR at Support**			
											DC1 (k)	31.8		
DEFLECTION LIMIT (x for Deflection Limit in L/x)	800										DC2 (k)	3.9		
											DW (k)	5.4		
Fatigue Design Life (yrs)	75				179298.4375						HL93 LL+IM (k) LLF = 1.75	89.4		
Fatigue ADTTSL	1000	Fatigue I Controls												
											Vu (k)	209.2		
											Vn (k)	591.9		
											SHEAR PR	**0.353**		

Demonstration: 62 ft Span, 8” Deck w/SIP, 4 Girders @ 9 ft

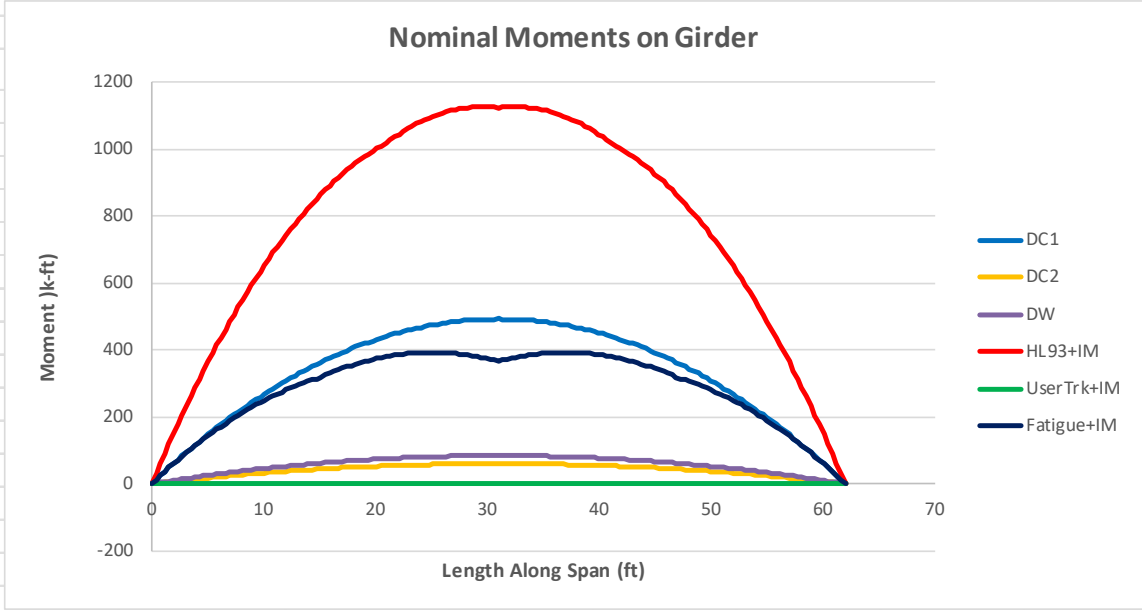
Composite Bridge

	STRENGTH I/II		Compression Flange Laterally Braced for F			LLF = 1.75							
		Lb (ft)	DC1 (ft-k)	DC2 (ft-k)	DW (ft-k)	HL93 LL+IM (ft-k)		Mu (ft-k)	Cb	Mn (ft-k)	Perf Ratio		
	1	21	441.1	53.8125	75.3	1000.4		2482.4	1.42	3444.0	0.721		STRENGTH I/II MAX PR
	2	20	492.3	60.0625	84.1	1093.4		2730.1	1.01	3444.0	0.793		0.793
	3	21	441.1	53.8125	75.3	1000.7		2482.8	1.43	3444.0	0.721		
Strength Design Uses AASHTO Appendix A6	**CONSTRUCTION**						<0.60Fy		RpcFy=1.16*50				
		Lb (ft)	Mconstr (ft-k)	Mlat (ft-k)	AF	Affl (ksi)	Perf Ratio	fbu+Affl (ksi)	Perf Ratio	ɒu+1/3Affl (ks	Fnc (ksi)	Perf Ratio	
	1	21	791.4	21.6	1.4	18.6	0.62	40.2	0.80	27.8	55.9	0.50	CONSTRUCTION MAX PR
	2	20	883.3	19.9	1.8	23.2	0.77	47.4	0.95	31.9	40.9	0.78	0.947
	3	21	791.4	21.6	1.4	18.6	0.62	40.2	0.80	27.8	55.9	0.50	
DEAD LOAD DEFLECTIONS (Max Loaded Girder)			0	0.10L	0.20L	0.30L	0.40L	0.50L	0.60L	0.70L	0.80L	0.90L	L
		Distance (ft)	0	6.2	12.4	18.6	24.8	31	37.2	43.4	49.6	55.8	62
Ix (in^4) =	7800.0	DC1 (in)	0.000	0.473	0.894	1.224	1.434	1.506	1.434	1.224	0.894	0.473	0.000
I3n (in^4) =	15409.5	DC2 (in)	0.000	0.029	0.055	0.076	0.089	0.093	0.089	0.076	0.055	0.029	0.000
I3n (in^4) =	15409.5	DW (in)	0.000	0.041	0.077	0.106	0.124	0.130	0.124	0.106	0.077	0.041	0.000
		Total (in)	0.00	0.54	1.03	1.41	1.65	1.73	1.65	1.41	1.03	0.54	0.00

Demonstration: 62 ft Span, 8” Deck w/SIP, 4 Girders @ 9 ft

Composite Bridge

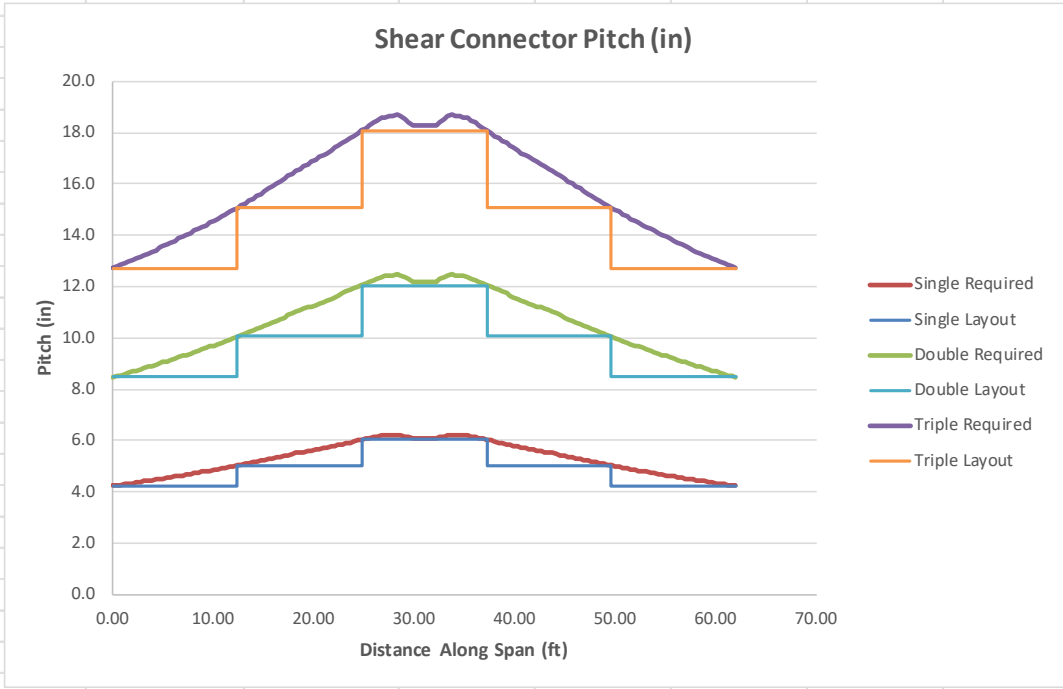
NOMINAL ABUTMENT REACTIONS		
DC1 (k)	123.3	At Centerline
DC2 (k)	15.5	At Centerline
DW (k)	21.7	At Centerline
Single Lane LL+IM (k)	121.4	At 9.00 From Centerline
Two Lane LL+IM (k)	202.4	At 4.00 From Centerline



Demonstration: 62 ft Span, 8” Deck w/SIP, 4 Girders @ 9 ft

Composite Bridge – Shear Studs

ONLY IF COMPOSITE															
0.875 (in) SHEAR STUDE SPACING		Minimum Spacing (in)	3.5				Maximum Spacing (in)	48		Minimum Transverse Spacing (in)	3.5		d (in)	35.6	
		0 - 12.4 ft	12.4 - 24.8 ft	24.8 - 37.2 ft	37.2 - 49.6 ft	49.6 - 62.0 ft							bf (in) =	12	
	Singles Pitch (in)	4.23	5.03	6.03	5.03	4.23									
	Doubles Pitch (in)	8.47	10.05	12.06	10.05	8.47							Doubles Transverse Spacing		
	Triples Pitch (in)	12.70	15.08	18.08	15.08	12.70							Triples Transverse Spacing C		
	Strength Minimum Number of Studs	127													
	Fatigue Singles Estimated Number of Studs	155.172541													
	Fatigue Doubles Estimated Number of Studs	156.172541													
	Fatigue Triples Estimated Number of Studs	157.172541													



0
12.4
12.4
24.8
24.8
37.2
37.2
49.6
49.6
62

eBEAM140 Summary

Rolled Shape Bridge Design: Composite & NonComposite

- AASHTO 10th Edition
- User Manual & Examples
- Released on www.ShortSpanSteelBridges.org September 2025
  https://www.shortspansteelbridges.org/ebeam140/

Plate Girder Bridge Design in 2026

SOON Short Span Steel Bridge Alliance ePLATE140

Noncomposite and Composite Simple-Span Plate-Girder Steel Bridge Design

ePLATE140

Excel Based Prismatic Plate Girder Design Software

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SIMILAR

ePLATE140 Design Software - 2026

Excel Based Plate Girder Design Software

- Allows User to Investigate Alternatives to
  - Diaphragm Spacing
  - Lightest Weight Solution
  - Other Readily Available Flanges & Webs

Target L/D:

- Target L/D – 2”
- Target L/D
- Target L/D + 2”
- Target L/D + 4”
- Target L/D + 6”

5 different Web Depths

5100 possible design combinations User Specified Solution

ENTER SECTION FOR MORE INFORMATION

bfc	tfc	D	tw	bft	tft	Weight (lb/ft)	Total Wt (tons)
13.00	0.750	38.00	0.500	17.00	0.750	141	22.6

OVERALL PERFORMANCE FOR TF:13 x 0.75 Web:38 x 0.5 BF:17 x 0.75

Strength I/II	Service II	Construction	Fatigue	Deflection	Overall
PR	PR	PR	PR	PR	PR
0.917	0.973	0.933	0.703	0.807	0.973
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to	Service II
3		2		L/992	Construction Uses A6

PERFORMANCE BY UNBRACED LENGTH FOR TF:13 x 0.75 Web:38 x 0.5 BF:17 x 0.75

Compression Flange Laterally Braced for Final State			Strength I/II		
Unbraced Length	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb
1	20	0 - 20 ft	0.703	1.995	1.509
2	20	20 - 40 ft	0.917	1.995	1.052
3	20	40 - 60 ft	0.917	1.995	1.052
4	20	60 - 80 ft	0.703	1.995	1.509

bfc>=D/6 OK
bfc/2tfc<=12 OK
D/tw<=150 OK
2Dcp/tw<=lrw OK
Iyc/Iyt>=0.3 OK
Meets Reqrments for A6?
Yes
Construction Uses A6

LIST OF GIRDERS RANKED FROM STRENGTH I, SERVICE II & CONSTRUCTION

Shape	Strength I/II PR	Service II PR	Construction PR	Fatigue PR	Deflection PR	Overall PR	Total Wt (tons)
TF:13 x 0.75 Web:38 x 0.5 BF:17 x 0.75	0.92	0.97	0.93	0.70	0.81	0.97	22.6
TF:13 x 0.75 Web:38 x 0.5 BF:13 x 1	0.91	0.97	0.93	0.69	0.80	0.97	22.7
TF:14 x 0.75 Web:36 x 0.5 BF:18 x 0.75	0.95	0.99	0.87	0.72	0.87	0.99	22.9
TF:13 x 0.75 Web:38 x 0.5 BF:18 x 0.75	0.89	0.94	0.93	0.68	0.78	0.94	23.0
TF:14 x 0.75 Web:38 x 0.5 BF:17 x 0.75	0.92	0.97	0.81	0.70	0.81	0.97	23.0
TF:14 x 0.75 Web:34 x 0.5 BF:15 x 1	0.97	0.99	0.93	0.71	0.91	0.99	23.1
TF:14 x 0.75 Web:36 x 0.5 BF:14 x 1	0.94	0.97	0.86	0.70	0.85	0.97	23.1
TF:15 x 0.75 Web:36 x 0.5 BF:18 x 0.75	0.95	0.99	0.78	0.72	0.87	0.99	23.3
TF:13 x 0.75 Web:38 x 0.5 BF:14 x 1	0.88	0.92	0.92	0.66	0.76	0.92	23.3
TF:14 x 0.75 Web:38 x 0.5 BF:18 x 0.75	0.89	0.94	0.81	0.68	0.78	0.94	23.4
TF:15 x 0.75 Web:38 x 0.5 BF:17 x 0.75	0.92	0.97	0.73	0.70	0.81	0.97	23.4
TF:15 x 0.75 Web:34 x 0.5 BF:15 x 1	0.97	0.99	0.83	0.71	0.91	0.99	23.5
TF:14 x 0.75 Web:34 x 0.5 BF:16 x 1	0.94	0.94	0.93	0.68	0.87	0.94	23.7
TF:12 x 1 Web:36 x 0.5 BF:18 x 0.75	0.95	0.99	0.88	0.72	0.87	0.99	23.7
TF:14 x 0.75 Web:36 x 0.5 BF:15 x 1	0.91	0.93	0.86	0.67	0.81	0.93	23.7
TF:16 x 0.75 Web:36 x 0.5 BF:18 x 0.75	0.96	0.99	0.72	0.72	0.87	0.99	23.7
TF:14 x 0.75 Web:38 x 0.5 BF:14 x 1	0.88	0.92	0.80	0.66	0.76	0.92	23.7

ePLATE140 Plans

Plate GirderBridge Design: Composite & NonComp

AASHTO 10th Edition

Develop Users Manual & Examples

Industry Review

Release Sept 2026

Resource Tools for Simple Span Steel Bridge Design

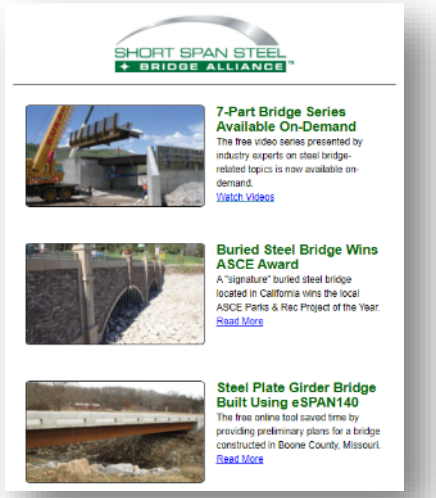
Preliminary Composite Rolled Shape and Plate Girder

Optimized Composite & NonComposite Rolled Shape

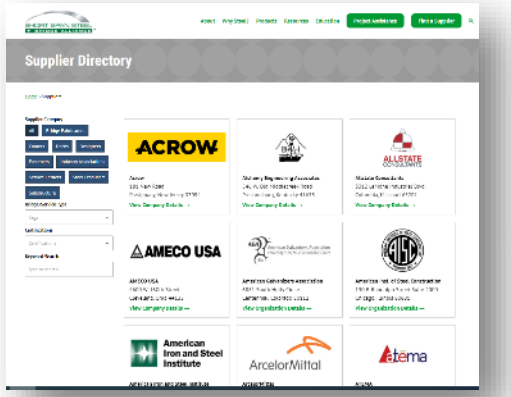
Optimized Composite & NonComposite Plate Girder

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™

eBEAM140

4. Receive Free Project Assistance

5. Schedule a Workshop/Webinar

www.ShortSpanSteelBridges.org

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

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