AASHTOWare BrDR 7.5.0 Steel Tutorial STL7 – Steel Shear Stud Design Tool

BrDR Tutorial

Topics Covered

- Importing a bridge in BrDR
- Shear Stud Design Tool
- Shear Stud Design Tool Design Rules
- LRFD Design Review

Importing a bridge in BrDR

This example uses the bridge defined in the **STL7-Steel-Shear-Stud-Wizard.xml** provided for this tutorial. Use the **Import** function of **BrDR** to import this bridge. Open **BrDR** and click on the **Import** button from the **Bridge** group of the **BRIDGE** ribbon as shown below.

AASHTOW	/are Bridge De	sign and	d Rating 📍 — 🛛	×
BRIDGE EXPLORER BRIDGE	FOLDER	RATE	TOOLS VIEW	
New Open Open	Find Copy	Paste	Copy To • Remove From Delete	
Bridge		M	anage	
← ☆ Favorites Folder ← Ø Recent Bridges ← Ø All Bridges ☆ Ø Templates ← Ø Deleted Bridges		E 1 2 3 4 5	Bridge ID TrainingBridge1 TrainingBridge2 TrainingBridge3 PCITrainingBridge1 PCITrainingBridge2	•
I	Total Bridge Co	ount:	32	

Select the bridge and click the **Open** button to import this bridge into **BrDR**.

📲 Import					×
\leftarrow \rightarrow \checkmark \uparrow \blacksquare \Rightarrow This	PC > Desktop > STL7	~	ට 🔎 Search	STL7	
Organize 🔻 New folder					?
This PC	Name	Date modified	Туре	Size	
3D Objects	STL7-Steel-Shear-Stud-Design-Tool	11/3/2022 10:12 AM	XML Document	562 KB	
Desktop Documents Downloads Music Dictures Videos G (C:) DATA (D:) Network V					
File nar	me: STL7-Steel-Shear-Stud-Design-Tool		 ✓ AASHTOWar Open 	e Bridge XML (.xm Cancel	~

Shear Stud Design Tool

Expand the **Bridge Workspace** tree to show the member alternative for member **G2**. The partially expanded **Bridge Workspace** tree is shown below.

Workspace _ 🗆 X Bridge Components 🖮 🙈 Stl6_Training 📁 Components 📁 Diaphragm Definitions 📁 Lateral Bracing Definitions MPF LRFD Multiple Presence Factors **EC** Environmental Conditions DP Design Parameters SUPERSTRUCTURE DEFINITIONS Η 2 Span, 4 Girder system 📑 Impact/Dynamic Load Allowance HI Load Case Description 🛲 Framing Plan Detail 📁 Bracing Deterioration BSC Bracing Spec Check Selection Structure Typical Section ₩ Superstructure Loads 📁 Shear Connector Definitions Stiffener Definitions
 MEMBERS i∎ I G1 I G2 🕂 Member Loads ⊼ Supports E MEMBER ALTERNATIVES I Plate Girder (E) (C) ∎ Default Materials ➡ Impact/Dynamic Load Allowance 📼 Girder Profile Hinge Locations 📁 Splice Locations 📼 Deck Profile R Haunch Profile 🞞 Lateral Support 🞞 Stiffener Ranges 📁 Bearing Stiffener Locations LL Live Load Distribution 📁 Points of Interest Im Deterioration Profile I Plate Girder - Allow Moment Redistribution I G3 由 I G4 🗄 - 📊 Corrugated Deck - Steel Beam BRIDGE ALTERNATIVES 卣 Bridge Alternative 1 (E) (C)

Deck Profile

Double click on the **Deck Profile** node in the **Bridge Workspace** tree to open the **Deck Profile** window. Navigate to the **Shear connectors** tab of this window. The shear connectors are currently defined as a generic **Composite** region. **BrDR** has a **Shear stud design tool** that can compute a shear stud pattern. Click the **Shear stud design tool** button in this window as shown below.

4	Dec	ck Profile															-		×
Т	/pe:	Plate																	
	De	ck concrete	Reinfor	cement	Shear co	nnectors													
		Support number	Start distance (ft)	Length (ft)	End distance (ft)	Connecto	or	Number of spaces	Number per row	Transverse spacing (in)	•								
	Þ	1 *	0.00	180.00	180.00	Composite	*											1	h.
																			v
		Shear stud design too	і ы	View calcs										New	1	Duplicate		Delete	
														(DK	Appl	у	Cance	el

Enter the data as shown below. If the **Provide shear studs in negative flexure regions** is not checked, the design tool will not create a stud pattern in the negative moment region between points of dead load contraflexure.

tud diameter:	0.875 in	Design template:	HL 93 Design Re	view 🗸 View	<i></i>
Provide sh	ear studs in negat	ive flexure regions			
plice location g	gaps				
Support	Splice	location	Loft con	Pight gap	
number	Left or right of support	Distance (ft)	(ft)	(ft)	

Click the **Continue** button and the **Shear Stud Design Tool Progress** window will launch a dead load and live load analysis, design a shear stud pattern, and display the resulting design as shown below.

Click **OK** to view the results.

🕰 Shear Stud Design Tool Progress	\times
- Location - 04.0000 (it)	•
- Location - 70.5000 (ft)	<u> </u>
- Location - 72.0000 (ft)	
- Location - 77.0000 (ft)	
- Location - 81.0000 (ft)	
- Location - 83.5000 (ft)	
- Location - 90.0000 (ft)	
- Location - 96.5000 (ft)	
- Location - 99.0000 (ft)	
- Location - 103.0000 (ft)	
- Location - 108.0000 (ft)	
- Location - 109.5000 (ft)	
- Location - 116.0000 (ft)	
- Location - 117.0000 (ft)	
- Location - 126.0000 (ft)	
- Location - 132.0000 (ft)	
- Location - 135.0000 (ft)	
- Location - 144.0000 (ft)	
- Location - 148.0000 (ft)	
- Location - 153.0000 (ft)	
- Location - 162.0000 (ft)	
- Location - 164.0000 (ft)	
- Location - 171.0000 (ft)	
- Location - 180.0000 (ft)	
Finding maximum stresses in the unbraced lengths	
Finished finding maximum stresses in the unbraced lengths	
Info: - Start Genetic Algorithm to optimize the shear stud design	
Info: - Initializing optimization based on user input, cross sections, and assumptions	
Info: - Optimizing solution	
Info: - Optimization successfully finished. Please review the calculations.	
Info: Shear stud design analysis successfully completed!	
Analysis completed!	
	\sim
Print Of	(

omputed itud name iteel minii itud heigh tud diam	a snear conne e: imum tensile ht: neter:	strength: 6	/izard Stu 0	ld ksi					
teel mini tud heigł tud diam	e. imum tensile ht: neter:	strength: 6	0	ksi in					
tud heigl tud diam	ht: ht:	strengtn: 6	0	in					
tud heigi tud diam	ht: neter:	6		10					
tud diam	neter:								
		0	.875	in					
omputed	shear conne	ctor ranges							
emparcu	shear conne	a c						-	
Sunu	ipport imber	Start distance (ft)	Le	ength (ft)	End distance (ft)	Number per row	Number of spaces	Iransverse spacing (in)	
> 1	\sim	C		36	36	3	72	4.5	A
1	~	36	5	54	90	2	107	9.1	
2	~	C		54	54	3	107	4.5	
2	~	54	L .	36	90	3	72	4.5	

The **Stud name** and the range data can be modified in this window. Click the **Apply** button to save the generated data. Note that clicking the **Apply** button deletes the existing ranges.

Close the window by clicking **OK**. This applies the data and closes the window.

The **Shear connectors** tab will updates with the shear stud ranges created using the **Shear stud design tool** as shown below. The **View calcs** button on this window opens a text file containing the output of the articles that were evaluated in the design.

A 1	Deck	Profile										-		×
Ту	e:	Plate												
1	Deck	concrete	Reinford	cement	Shear cor	nnectors								
		Support number	Start distance (ft)	Length (ft)	End distance (ft)	Conne ID	ector	Number of spaces	Number per row	Transverse spacing (in)				
	>	1 ~	0	36	36	Wizard Stud	\sim	71	3	4.5				
		1 ~	36	54	90	Wizard Stud	\sim	107	2	9.1				
		2 ~	0	54	54	Wizard Stud	\sim	107	3	4.5				
		2 ~	54	36	90	Wizard Stud	\sim	72	3	4.5				
		Share a bud		View										Ŧ
		design too		calcs							New	Duplicate	Delete	
											UK	Арріу	Cano	ei

 Results of the Shear Stud Wizard
 Executed on 1/9/2024 2:02 PM ^ Load Combination Legend: Code Vehicle 1 HL-93 (US) - Design Truck + Lane 2 HL-93 (US) - Tandem + Lane 3 HL-93 (US) - 90%(Truck Pair + Lane) 4 LRFD Fatigue Truck (US) - Fatigue Truck 6 Steel Structures 6.10 I-Section Flexural Members 6.10.10 Shear Connectors 6.10.10.1 General (AASHTO LRFD Bridge Design Specifications, Ninth Edition) Steel Plate - At Location = 0.0000 (ft) - Right Stage 3 Section within Top Flange Continuous Bracing Region Section at Bottom Flange Brace Point INPUT: Shear Connector Type: Stud
 Snear connector lype: Stud

 Stud Diametr, Diame
 0.8750 (in)

 Stud Height, H
 = 6.0000 (in)

 Number per Row
 = 3

 Transverse Spacing
 = 4.50 (in)

 Pitch
 = 6.0000 (in)
 Top Flange bf = 12.0000 (in) Haunch Depth = 1.0000 (in) Eff. Slab Thick = 8.0000 (in) 6.10.10.1.1 Types Stud H/Diam >= 4.0 Stud H/Diam = 6.8571 PASS 6.10.10.1.2 Pitch 1. C/C Pitch <= 48.0 in

Shear Stud Design Tool – Design Rules

- 1. The user enters the stud diameter.
- 2. The minimum tensile strength of the stud is always 60 ksi (415 MPa) as per AASHTO LRFD Article 6.4.4.
- 3. Designs are optimized such that all the following articles pass with a design ratio (i.e., resistance/action) close to 1.1.
- 4. The Wizard evaluates the following specification articles:
 - a. 6.10.10.1.1 Shear Connectors General Types
 - b. 6.10.10.1.2 Shear Connectors General Pitch
 - c. 6.10.10.1.3 Shear Connectors General Transverse Spacing
 - d. 6.10.10.1.4 Shear Connectors General Cover and Penetration
 - e. 6.10.10.2 Shear Connectors Fatigue Resistance
 - f. 6.10.10.3 Shear Connectors Special Requirements for Points of Permanent Load Contraflexure (only evaluated at points of dead load contraflexure when the user has chosen to not provide shear studs in the negative flexure regions)
 - g. 6.10.10.4 Shear Connectors Strength Limit State (only evaluated at points of maximum live load moment and interior supports as per this article)

LRFD Design Review

To perform an LRFD design review, select the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon. The window shown below opens.

Br		Bridge W	/orkspace	- Stl6_Training	9		ANALYS	IS	REPORT	rs	?	-	×
BRIDGE	WORKSF	ACE	WORKSPA	ACE TOOL	.S VIE	W	DESIGN/R	ATE	REPORTI	NG			^
*	65₹				\$	*	P.						
Analysis Settings	Analyze	Analysis Events	Tabular Results	Specification Check Detail	Engine Outputs	Results Graph	Save Results						
\square	Analysis			R	esults								

Click the Open Template button and select the HL-93 Design Review used in the rating and click Open.

Templates	Description	Analysis	Owner	Public / Private	
HL 93 Design Review	HL 93 Design Review	LRFD		Public	
HS 20 LFD Rating	HS 20 LFD Rating	LFR		Public	
LRFR Design Load Rating	LRFR Design Load Rating	LRFR		Public	
LRFR Legal Load Rating	LRFR Legal Load Rating	LRFR		Public	

nalysis Settings	
Design review CRating	Design method:
lysis type: Line Girder	~
e / Impact loading type: As Requested	✓ Apply preference setting: None
ehicles Output Engine Description	
raffic direction: Both directions	Refresh Temporary vehicles Advanced
/ehicle selection	Vehicle summary
 →Vehicles →Standard →Alternate Military Loading →EV2 →EV3 →HL-93 (JI) →HL-93 (US) →HS 20 (SI) →HS 20 (SI) →LRFD Fatigue Truck (JS) →Colorado Legal Type 3 →Colorado Legal Type 322 →Colorado Legal Type 322 →Colorado Legal Type 32 →Colorado Legal Type 32 →Colorado Legal Type 32 →Interstate Legal Type 32<!--</td--><td>Add to Add to</td>	Add to Add to

The Analysis Settings window will be populated as shown below.

Click **OK** to apply the analysis settings and close the window.

Next click the Analyze button on the Analysis group of the DESIGN/RATE ribbon to perform the rating.



Specification Check Detail

The specification checks can be viewed by selecting the **Specification Check Detail** button from the **Results** group of the **DESIGN/RATE** ribbon.

Bridge Wo	orkspace - Stl6_Training	9	ANALYSI	S REPORTS	?	_	×
BRIDGE WORKSPACE	NORKSPACE TOOL	.S VIEW	DESIGN/RA	REPORTING			^
Analysis Analyze Analysis Settings Analysis Analysis	Tabular Results Check Detail	Engine Re Dutputs Gr esults	sults Save Results				

Select the 6.10.10.1 Shear Connectors - General article for Stage 3 at Span 2 – 90.00 ft.

Specification (Checks for Plate	Girder - 49 of 1	44		-		\times
		Articles					
		All articles	\checkmark				
Properties	Generate	Format					
		Bullet list	v				
pecification filter		Report					
🔺 🚞 Superstruc	cture Componen	t	Specification reference Limit State Fl	ex. Sense	Pass/Fail		^
🕨 🚞 Stage 1	1		🖹 1.3.2.1 Design Philosophy - Limit State - General N	I/A	General Co	omp.	
🕨 🚞 Stage 2	2		✓ 2.5.2.6.2 Criteria for Deflection N	I/A	Passed		
🔺 🚞 Stage 3	3		4.6.2.7.1 I-Sections - Lateral Wind Load Distribution in Multibeam Brid	I/A	General Co	omp.	- 1
🔺 🚞 Plat	te Girder		5.4.2.6 Modulus of Rupture	I/A	General Co	omp.	- 1
<u> </u>	Span 1 - 0.00 ft	·	6.10.1.1.1b Stresses for Sections in Positive Flexure	I/A	General Co	omp.	- 1
<u> </u>	Span 1 - 9.00 ft	·	🖹 6.10.1.10.1 Hybrid Factor, Rh 🛛 🔊	I/A	General Co	omp.	
<u> </u>	Span 1 - 16.00 f	ft.	6.10.1.10.2 Web Load-Shedding Factor, Rb	I/A	General Co	omp.	
<u> </u>	Span 1 - 18.00 f	ft.	✓ 6.10.1.6 Flange Stress and Member Bending Moments	I/A	Passed		
<u> </u>	Span 1 - 27.00 f	ft.	✓ 6.10.1.7 Minimum Negative Flexure Concrete Deck Reinforcement	J/A	Passed		
	Span 1 - 32.00 f	ft.	6.10.1.9.1 Webs without Longitudinal Stiffeners	J/A	General Co	omp.	- 1
	Span 1 - 36.00 f	ft.	✓ 6.10.10.1 Shear Connectors - General	J/A	Passed		
	Span 1 - 45.00 f	ft. 🕻	✓ 6.10.10.1.2 Pitch	I∕A	Passed		
	Span 1 - 48.00 f	t.	6.10.10.2 Fatigue Resistance	J/A	General Co	omp.	
	Span 1 - 54.00 f	ft.	✓ 6.10.11.1.2 Transverse Stiffeners - Projecting Width	V/A	Passed	1	- 1
	Span 1 - 63.00 f	t.	✓ 6.10.11.1.3 Transverse Stiffeners - Moment of Inertia	1/A	Passed		- 1
	Span 1 - 64.00 f	t.	✓ 6.10.11.2.2 Projecting Width	J/A	Passed		- 1
	Span 1 - 70.501	t.	✓ 6.10.11.2.3 Rearing Stiffeners - Bearing Resistance	J/Δ	Passed		
	Span 1 - 72.001	п. ь	✓ 6.10.11.2.4 Axial Resistance of Bearing Stiffeners	J/A	Passed		
_	Span 1 - 77.001	π. 	✓ 6102 Cross-Sertion Proportion Limits	1/Δ	Passed		
	Span 1 - 81.001	п. ь		1/A	Passed		
	Span 1 - 65.501	ц. ц.	NA 610.52 Spacial Estique Requirement for Webs	1/A	Not Applic	able	- 1
	Span 1 - 90.001		610.62.2 Composite Sections in Paritive Flowurs	1/A	General Co	able	- 1
	Span 2 - 0.30 ft		6.10.6.2.2 Composite Sections in Positive Flexure	1/A	General Co	omp.	- 1
	Span 2 - 12.00 ft	A	6.10.7.1.1 Concerned	1/A	General Co	omp.	- 1
	Span 2 - 18.00	A	✓ 0.10.7.1.1 General	1/A	Passed		- 1
	Span 2 - 1950	A	0.10.7.1.2 Nominal Flexural Resistance	1/A	General Co	omp.	- 1
	Span 2 - 26.00 f	A	NA 6.10.7.2.1 General	1/A	Not Applic	able	- 1
	Span 2 - 27.00	A	6.10.7.2.2 Nominal Flexural Resistance	I/A	General Co	omp.	- 1
	Span 2 - 36.00 f	A	✓ 6.10.7.3 Flexural Resistance - Ductility Requirement N	I/A	Passed		- 1
	Span 2 - 42.00 f	ft.	NA 6.10.8.1.1 Discretely Braced Flanges in Compression N	I/A	Not Applic	able	
	Span 2 - 45.00 f	ft.	NA 6.10.8.1.2 Discretely Braced Flanges in Tension N	I/A	Not Applic	able	
	Span 2 - 54.00 f	t.	NA 6.10.8.1.3 Continuously Braced Flanges in Tension or Compression	I/A	Not Applic	able	
	Span 2 - 58.00 f	t.	6.10.8.2.1 General	I/A	General Co	omp.	
 [=	Span 2 - 63.00 f	ft.	6.10.8.2.2 Local Buckling Resistance	I/A	General Co	omp.	
	Span 2 - 72.00	t.	6.10.8.2.3 Lateral Torsional Buckling Resistance	I/A	General Co	omp.	
	Span 2 - 74.00 f	ft.	6.10.8.2.3.Cb Lateral Torsional Buckling Resistance - Cb Calculation	I/A	General Co	omp.	
	Span 2 - 81.00 f	ft.	6.10.8.2.3.rt Lateral Torsional Buckling Resistance - rt and Lp Calculatio	I/A	General Co	omp.	
<u>_</u>	Span 2 - 90.00 f	ft.	6.10.8.3 Tension-Flange Flexural Resistance	I/A	General Co	omp.	
			✓ 6.10.9 Shear Resistance N	I/A	Passed		
			6 10 0 1 Shear Resistance - General	1/A	General Co	mn	~

🔐 Spec Check Detail for 6.10.10.1 Shear Connectors - General _ × 6 Steel Structures 6.10 I-Section Flexural Members 6.10.10 Shear Connectors 6.10.10.1 General (AASHTO LRFD Bridge Design Specifications, Ninth Edition) Steel Plate - At Location = 180.0000 (ft) - Left Stage 3 Section within Top Flange Continuous Bracing Region Section at Bottom Flange Brace Point INPUT: Shear Connector Type: Stud Stud Diameter, Diam = 0.8750 (in) Stud Height, H = 6.0000 (in) Number per Row = 3 Transverse Spacing = 4.50 (in) Pitch = 6.0000 (in) Top Flange bf = 12.0000 (in) Eff. Slab Thick = 8.0000 (in) INPUT: 6.10.10.1.1 Types Stud H/Diam >= 4.0 Stud H/Diam = 6.8571 PASS 6.10.10.1.2 Pitch 1. C/C Pitch <= 48.0 in Pitch = 6.0000 (in) PASS 2. C/C Pitch >= 6.0*Stud Diam
 6.0*Stud Diam = 5.2500 (in) PASS 6.10.10.1.3 Transverse Spacing 1. Trans Spacing >= 4.0*Stud Diam Trans Spacing = 4.50 (in) 4.0*Stud Diam = 3.5000 (in) PASS 2. Edge of flange to edge of conn (Clearance) >= 1.0 in Outside width of stud group = 9.8750 (in) Clearance = (bf - outside width)/2 = 1.0625 (in) PASS 6.10.10.1.4 Cover and Penetration I. Concrete cover >= 2.0 in Concrete cover = Slab thick + Haunch Depth - H = 3.0000 (in) PASS 2. Penetration into deck >= 2.0 in Penetration = H - Haunch Depth = 5.0000 (in) PASS SUMMARY: All limits are satisfied, article passes. _____ . ОК