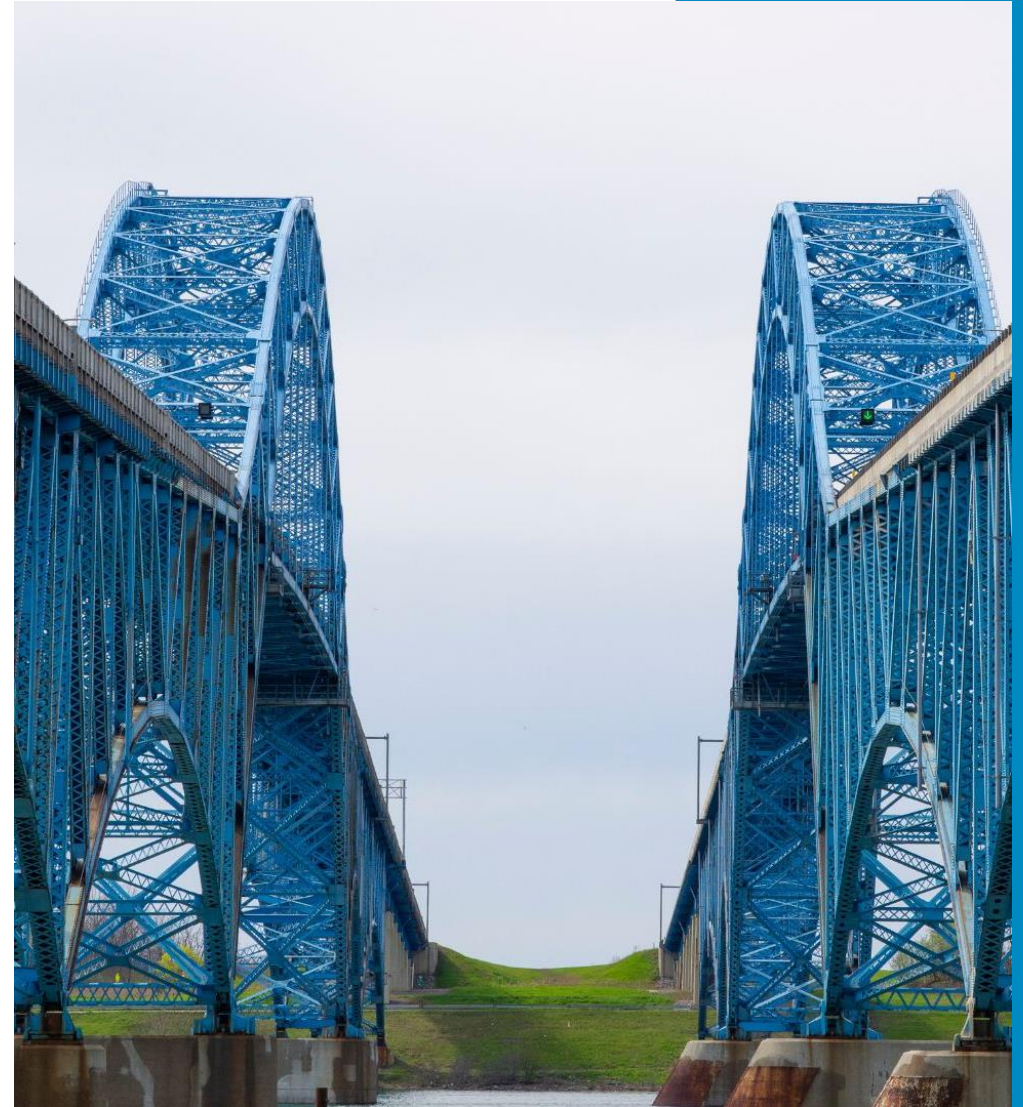


# Steel Design Tool

Carolyn Kois, P.E., ProMiles

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**RADBUG 2024 | August 6-7 | Buffalo, NY**



# Outline

- History
- Features
- Design Process and Philosophy
- Design Input
- Design Output
- Future Enhancements and Integration



# History

- Introduced with version v7.2
- Standalone tool with data export supported to BrDR
- Design based on AASHTO BDS LRFD 9<sup>th</sup> edition
- Design TAG Established in 2024 to investigate future enhancements
- Began plans to directly integrate into BrD



# Features

- Design for steel plate girders including hybrid girders
- Control options like BrD for advanced analysis
- Shear connector design tool
- Final design specification checking report
- Tabular results for dead and live load
- Beam profile schematic



# Design Process and Philosophy

- Input validation checks if a design is possible with the parameters, geometry and maximum plate sizes defined in the input
- Initial design for
  - Proportionality
  - Constructability
  - Permanent Deformation
  - Flexure and Fatigue
- Flange transitions
  - Simple spans at 20% and 80% points
  - Multi-span – based on uniform load contraflexure



# Design Process and Philosophy

- Shear design
  - Web thickness
  - Transverse stiffener design
  - Bearing stiffener design
- Optimize design
  - Lowest steel volume within input parameters
  - Design ratio greater than minimum design ratio



## Design Input

- Project
  - AASHTO LRFD Bridge Design Specification Edition
  - Limit states to consider
  - Design vehicles

The screenshot displays the 'Design Input' tab of the AASHTOWare Bridge Design: Steel Design Tool. The interface is organized into a sidebar on the left and a main content area on the right. The sidebar contains a 'Project' section with the following options: Project Library, Geometry, Deck, Typical Section Loads, Beam Parameters, Lateral Support, Member Loads, Control Options, and Input Report. The main content area is divided into several sections: 'Project' (Steel Design Example 2), 'Description' (4-girder, 5-span continuous steel hybrid plate girder), 'Designer' (empty field), 'Date' (1/1/2022), 'LRFD specifications' (Edition: AASHTO LRFD 9th), 'Limit states' (Strength-I, Strength-II, Strength-III, Strength-V, Service-II, Fatigue-I, Fatigue-II), and 'Design vehicles' (Design load: HL-93 (US), Permit load: 8-axle 204 kip Permit, Single lane permit load, Fatigue load: LRFD Fatigue Truck (US)).

2\_ST-5S-4G-C-0Skw-Gr50+70.brdx - AASHTOWare Bridge Design: Steel Design Tool

File Design Input Design

**Project**

Project Library

Geometry

Deck

Typical Section Loads

Beam Parameters

Lateral Support

Member Loads

Control Options

Input Report

Project: Steel Design Example 2

Description: 4-girder, 5-span continuous steel hybrid plate girder

Designer: [Empty Field]

Date: 1/1/2022 [Calendar Icon]

**LRFD specifications**

Edition: AASHTO LRFD 9th [Dropdown]

Limit states:  Strength-I  Strength-II  Strength-III  Strength-V  
 Service-II  
 Fatigue-I  Fatigue-II

**Design vehicles**

Design load: HL-93 (US) [Dropdown]

Permit load: 8-axle 204 kip Permit [Dropdown]

Single lane permit load

Fatigue load: LRFD Fatigue Truck (US) [Dropdown]

## Design Input

- Bridge Geometry
  - Number of spans and span length
  - Number of beams
  - Support skew
  - Number of design lanes
  - Support constraints

2\_ST-5S-4G-C-0Skw-Gr50+70.brdx - AASHTOWare Bridge Design: Steel Design Tool

File Design Input Design

Project

Project Library

**Geometry**

Deck

Typical Section Loads

Beam Parameters

Lateral Support

Member Loads

Control Options

Input Report

Number of spans: 5

Number of beams: 4

Girder spacing: 12 ft

Support skew: 0 Degrees

Number of design lanes: 3

Spans:

	Span	Length (ft)	
>	1	190.00	
	2	240.00	
	3	240.00	
	4	240.00	
	5	190.00	

Supports:

	Support	Support type	
>	1	Roller	
	2	Roller	
	3	Pinned	
	4	Pinned	



## Design Input

- Deck
  - Concrete Material
  - Reinforcement Material
  - Thickness
  - Overhang
- Haunch
- Composite or non-composite
- Shear connector detail

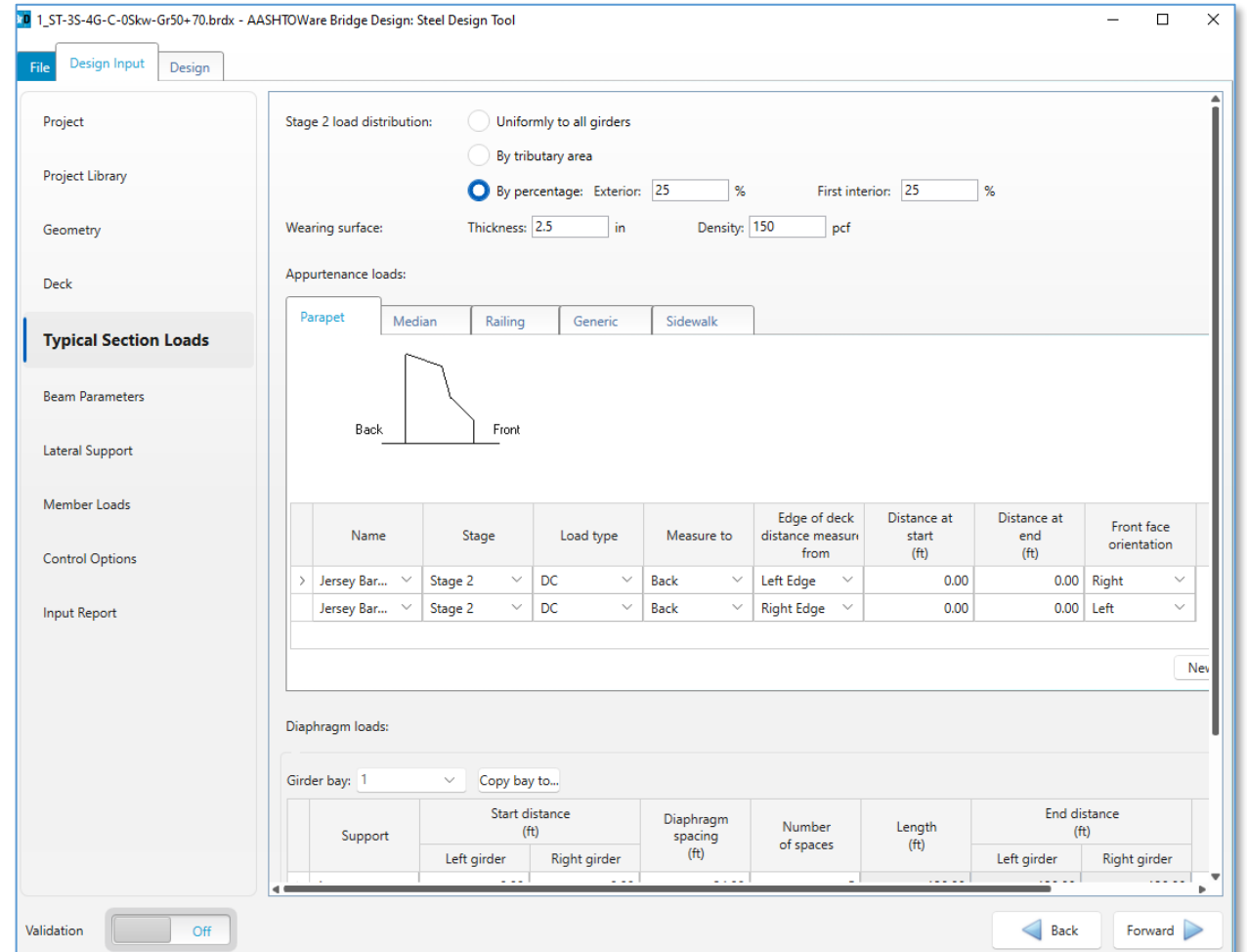
The screenshot displays the 'Design Input' tab of the AASHTOWare Bridge Design: Steel Design Tool. The interface includes a sidebar with navigation options: Project, Project Library, Geometry, **Deck**, Typical Section Loads, Beam Parameters, Lateral Support, Member Loads, Control Options, and Input Report. The main panel shows the following settings:

- Deck total thickness: 9.5 in
- Deck structural thickness: 9 in
- Deck reinforcement: Material: Grade 60
- Deck overhang: 3.5 ft
- Haunch depth: 4 in
- Edge of haunch to edge of beam: 0 in
- Composite deck
- Shear connectors: Stud diameter: 0.875 in,  Provide shear studs in negative flexure regions
- Splice location gaps: Table with columns for Support, Splice location (Left or right, Distance), Left gap (ft), and Right gap (ft).

Support	Start distance (ft)	Length (ft)	End distance (ft)	Bar size	Clear cover (in)	Measurement
> 1	0.00	455.00	455.00	6	2.0000	Top of Structural
1	0.00	455.00	455.00	5	1.5000	Bottom of Deck

## Design Input

- Typical Section Loads
  - Appurtenances
  - Wearing surface
  - Diaphragms
  - Load distribution method



## Design Input

- Member Loads
  - Distributed
  - Concentrated
  - Pedestrian

Beam	Name	Stage	Load type	Support	Start distance (ft)	Length (ft)	End distance (ft)
> 1	SIP forms	Stage 1	DC		0.00	1100.00	1100.00
1	Misc steel wei...	Stage 1	DC		0.00	1100.00	1100.00
2	SIP forms	Stage 1	DC		0.00	1100.00	1100.00
2	Misc steel wei...	Stage 1	DC		0.00	1100.00	1100.00
3	SIP forms	Stage 1	DC		0.00	1100.00	1100.00
3	Misc steel wei...	Stage 1	DC		0.00	1100.00	1100.00
4	SIP forms	Stage 1	DC		0.00	1100.00	1100.00
4	Misc steel wei...	Stage 1	DC		0.00	1100.00	1100.00

## Design Input

- Beam Parameters
  - Web depth
  - Top Flange and Bottom Flange
    - Min./Max. width and increment
  - Web, Top Flange, Bottom Flange
    - Min./Max. thickness and increment
  - Use transverse stiffeners
  - Steel materials
    - Web, top flange, bottom flange, transverse stiffeners, bearing stiffeners

The screenshot shows the 'Design Input' tab of the AASHTOWare Bridge Design: Steel Design Tool. The interface is divided into a sidebar on the left and a main configuration area on the right. The sidebar includes sections for Project, Project Library, Geometry, Deck, Typical Section Loads, **Beam Parameters** (selected), Lateral Support, Member Loads, Control Options, and Input Report. The main area is titled 'Section configuration' and contains three tables for defining beam properties:

Web	Min	Max	Increment
Depth	69 in	69 in	
Thickness	0.5000	0.6250	1/16"

Top flange	Min	Max	Increment
Width	16 in	18 in	2 in
Thickness	1.5000	2.1250	1/8"

Bottom flange	Min	Max	Increment
Width	18 in	20 in	2 in
Thickness	1.3750	2.0000	1/8"

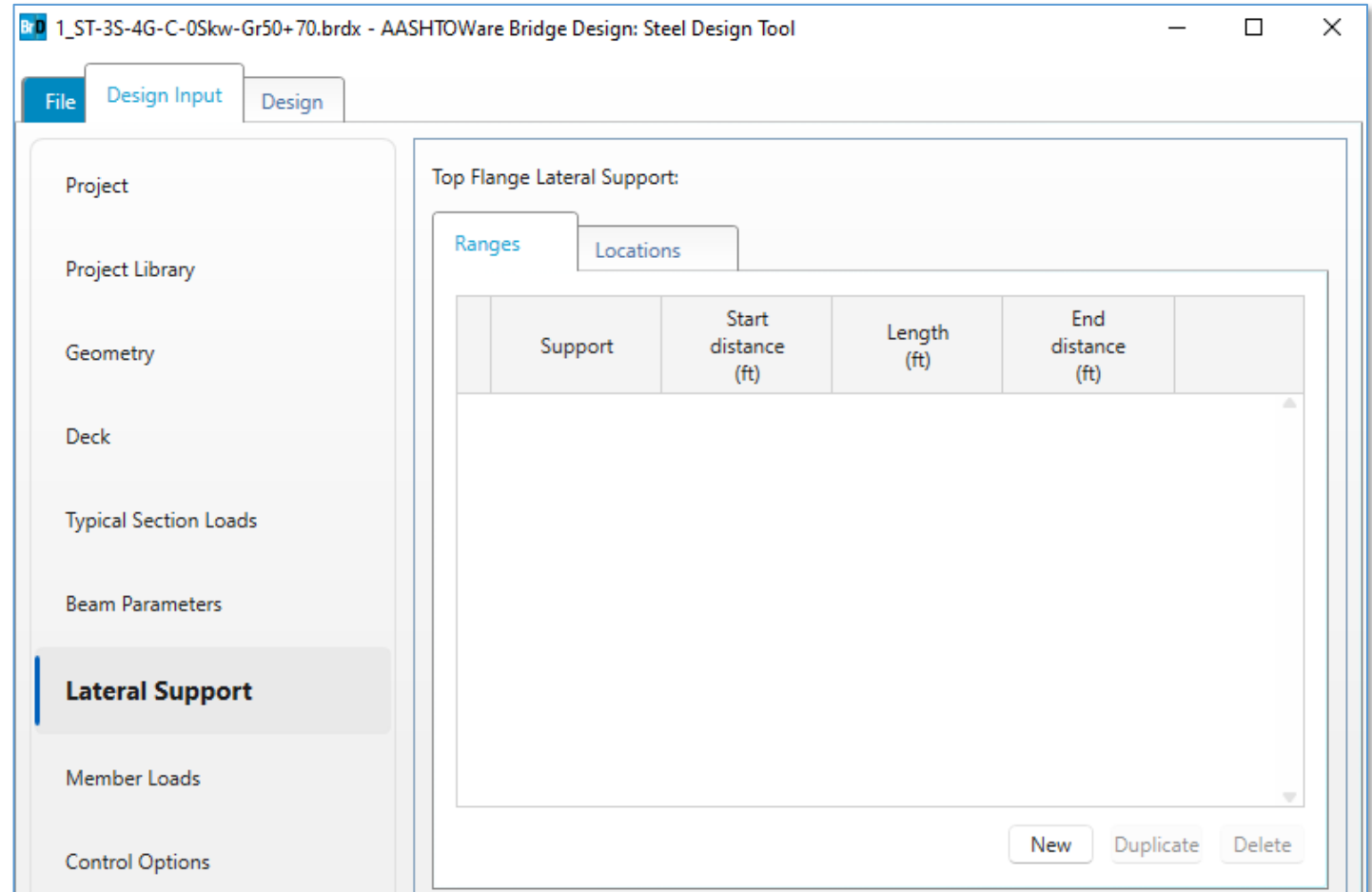
Below these tables, there is a checkbox for 'Use transverse stiffeners' which is checked. A table below it shows the configuration for exterior and interior stiffeners:

Beam	One sided	Max spacing (in)
> Exterior	<input checked="" type="checkbox"/>	207
Interior	<input checked="" type="checkbox"/>	207

The 'Structural steel materials' section includes dropdown menus for selecting materials for the Web, Top flange, Bottom flange, Transverse stiffener, and Bearing stiffener, all currently set to 'Grade 50W'. At the bottom, there is a 'Validation' button set to 'Off' and 'Back'/'Forward' navigation buttons.

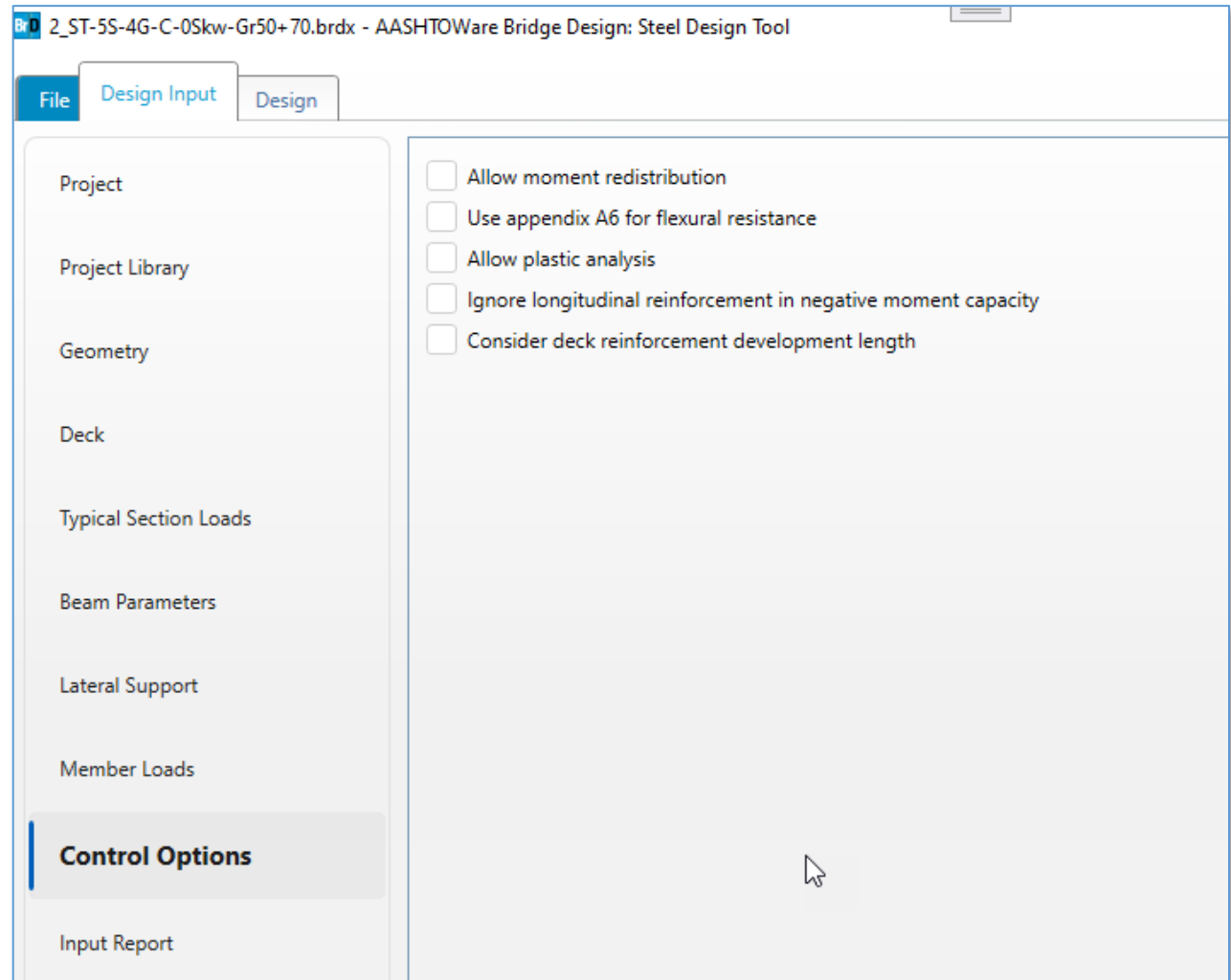
## Design Input

- Lateral Support
  - Top Flange Lateral Support
  - As a range
  - At discrete locations



## Design Input

- Control Options
  - Moment redistribution
  - Appendix A6
  - Plastic analysis
  - Longitudinal reinforcement in negative moment capacity
  - Deck reinforcement development length



## Design Output

Notes:

- \* All flange length dimensions are horiz. (length along flange may differ).
- \* Transverse stiffener pairs shown in red.
- \* Single transverse stiffener shown in blue.
- \* Bearing stiffeners shown in green.
- \* Dimensioning starts and ends at CL bearings.
- \* X denotes cross frame locations.

Girder profile | Stiffeners | Shear connectors | Schematics: Profile View

Shear Connectors

Stud Height: 6.000 in

Steel Minimum Tensile Strength: 60.000 ksi

Shear Connector	Number per Row	Number of Spaces	Transverse Spacing (in)	Support	Start Distance (ft)	Length (ft)	End Distance (ft)
> Shear Stud	2	26	9.100	1	0.000	33.000	33.000
Shear Stud	2	26	9.100	1	33.000	33.000	66.000

4\_ST-15-6G-C-35Skw-Gr50-Sdwlk.brdx - AASHTOWare Bridge Design: Steel Design Tool

File | Design Input | Design

Design Input | Design review |  Shear connector design

Beam: 1 | Minimum design ratio: 1

Design run | View results | Input and review | BrDR

Design run	Description	Critical design ratio	Pin
1-11.1	G1 - Design (Volume = 28.0ft^3)	✓ 1.010	-

Girder profile | Stiffeners | Shear connectors | Schematics: Profile View

Web:

Depth (in)	Thickness (in)	Support	Start distance (ft)	Length (ft)	End distance (ft)
> 20.000	0.500	1	0.000	66.000	66.000

## Design Output

- DL and LL Actions for each load case and load stage

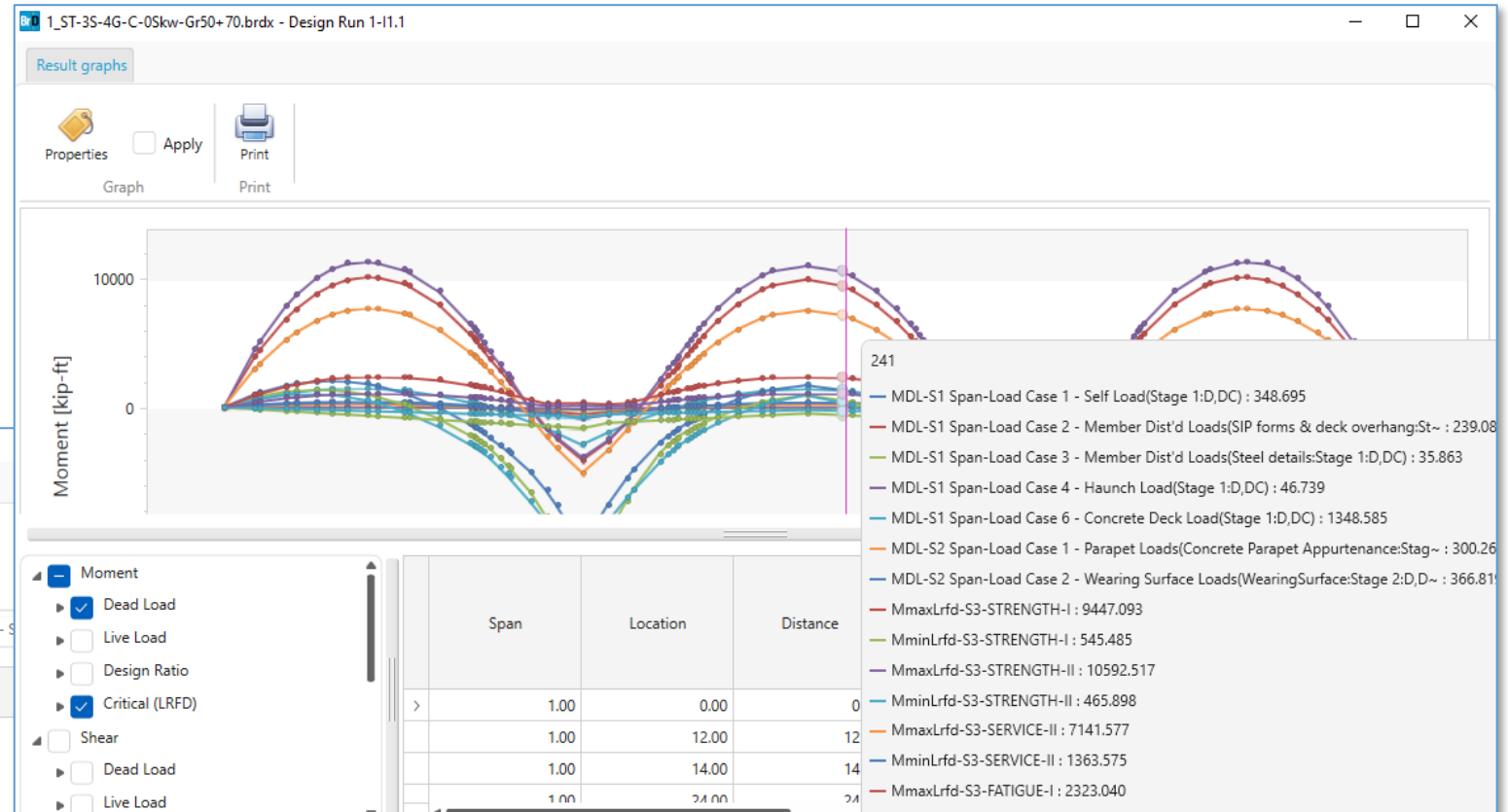
1\_ST-3S-4G-C-0Skw-Gr50+70.brdx - Design Run 1-11.1

Tabular results

Print

Report type: Dead Load Actions Stage: Stage 1 Dead load case: Load Case 1 - S

Span	Location	Moment (kip-ft)	Shear (kip)	Axial (kip)	Reaction (kip)	X deflection (in)	Y deflection (in)
1	0.00	0.00	18.03	0.00	18.03	0.0000	0.0000
1	12.00	191.82	13.94	0.00		0.0000	-0.1568
1	14.00	219.00	13.25	0.00		0.0000	-0.1816
1	24.00	334.45	9.84	0.00		0.0000	-0.2954
1	28.00	371.06	8.47	0.00		0.0000	-0.3350





## Design Output

- Detailed Specification Checks

1\_ST-3S-4G-C-0Skw-Gr50+70.brdx - Design Run 1-11.1

Specification checks

Properties  Apply  Generate

Articles: All articles

Format: Bullet list

Report

Specification filter

Superstructure Compon

- Stage 1
- Stage 2
- Stage 3
  - G1
    - Span 1 - 0.00
    - Span 1 - 12.00
    - Span 1 - 14.00
    - Span 1 - 24.00
    - Span 1 - 28.00
    - Span 1 - 36.00
    - Span 1 - 42.00
    - Span 1 - 48.00
    - Span 1 - 56.00
    - Span 1 - 60.00
    - Span 1 - 70.00
    - Span 1 - 72.00
    - Span 1 - 84.00
    - Span 1 - 96.00

Specification reference	Pass/Fail
1.3.2.1 Design Philosophy - Limit State - General	General Co
<b>2.5.2.6.2 Criteria for Deflection</b>	<b>Passed</b>
4.6.2.7.1 I-Sections - Lateral Wind Load Distribution in Multibeam Brid	General Co
5.4.2.6 Modulus of Rupture	General Co
5.4.2.8 Concrete Density Modification Factor	General Co
6.10.1 Estimated Flange Lateral Bending Stress Proportioning	General Co
6.10.1.1.1b Stresses for Sections in Positive Flexure	General Co
6.10.1.10.1 Hybrid Factor, Rh	General Co
6.10.1.10.2 Web Load-Shedding Factor, Rb	General Co
6.10.1.6 Flange Stress and Member Bending Moments	Passed
6.10.1.7 Minimum Negative Flexure Concrete Deck Reinforcement	Passed
6.10.1.9.1 Webs without Longitudinal Stiffeners	General Co
6.10.11.1.2 Transverse Stiffeners - Projecting Width	Passed
6.10.11.1.3 Transverse Stiffeners - Moment of Inertia	Passed
6.10.2 Cross-Section Proportion Limits	Passed
6.10.4.2.2 Flexure	Passed
NA 6.10.5.3 Special Fatigue Requirement for Webs	Not Applicable
6.10.6.2.2 Composite Sections in Positive Flexure	General Comp.

Spec Check Detail for 2.5.2.6.2 Criteria for Deflection

2 General Design and Location Features

2.5 Design Objectives

2.5.2 Serviceability

2.5.2.6 Deformations

2.5.2.6.2 Criteria for Deflection  
(AASHTO LRFD Bridge Design Specifications, Ninth Edition)

Steel Plate - At Location = 28.0000 (ft) - Right Stage 3

Section within Top Flange Continuous Bracing Region

Calculation of Deflection

-----

Span Length = 140.000 (ft)

Vehicular Load Deflection Limit = Span Length / 800 (Article 2.5.2.6.2)

Vehicular and/or Pedestrian Load Deflection Limit = Span Length / 1000 (Article 2.5.2.6.2)

HL-93 (US)

Vehicle	Deflection
Design Truck	-0.471 (inches)
Design Lane	-0.307 (inches)
Pedestrian	0.000 (inches)

Vehicle	Deflection (inch)	Deflection Limit (inch)	Design Ratio	Pass/Fail
Design Truck	-0.471	2.100	4.456	PASS
0.25*Design Truck + Design Lane	-0.424	2.100	4.948	PASS

OK

## Design Output

- Reports

1\_ST-3S-4G-C-0Skw-Gr50+70.brdx - Design Run 1-I1.1

Engine outputs

Properties Apply Open folder

Output

Category	Description
> Reinforcement Development Len...	Stage 2 Deck Reinforcement Development Length Calculations
Reinforcement Development Len...	Stage 3 Deck Reinforcement Development Length Calculations
FE Analysis	Stage 3 3 Infl Lines Finite Element Model and Load Cases
FE Analysis	Stage 3 3 Infl Lines Element Actions, Support Reactions, and Nodal Displacements
LL Distribution	Live Load Distribution Factors Calculations
LL Distribution	Live Load Distribution Factors Calculations Summary
Specification Checks	Stage 3 Spec Check Results

LRFD Dist Factor Summary.TXT - Notepad

File Edit Format View Help

Bridge: .  
 Bridge ID: NBI Structure ID:  
 BID:

Superstructure Def: .  
 Member: G1  
 Member Alternative: G1

Date: 8/2/2024 Time: 11:56:34 AM

AASHTO LRFD Bridge Design Specifications, Edition 9, Interim 0

Moment Distribution Factor Schedule

Start Distance (ft)	End Distance (ft)	Single Lane DF (Lanes)	Multi Lane DF (Lanes)
0.00	103.50	0.875(L)	
103.50	177.04	0.875(L)	
177.04	277.96	0.875(L)	
277.96	351.50	0.875(L)	
351.50	455.00	0.875(L)	

Shear Distribution Factor Schedule

Start Distance (ft)	End Distance (ft)	Single Lane DF (Lanes)	Multi Lane DF (Lanes)
0.00	140.00	0.875(L)	
140.00	315.00	0.875(L)	
315.00	455.00	0.875(L)	

Deflection Distribution Factor Schedule

Start	End	Single Lane	Multi Lane

BrDR XML Report Viewer

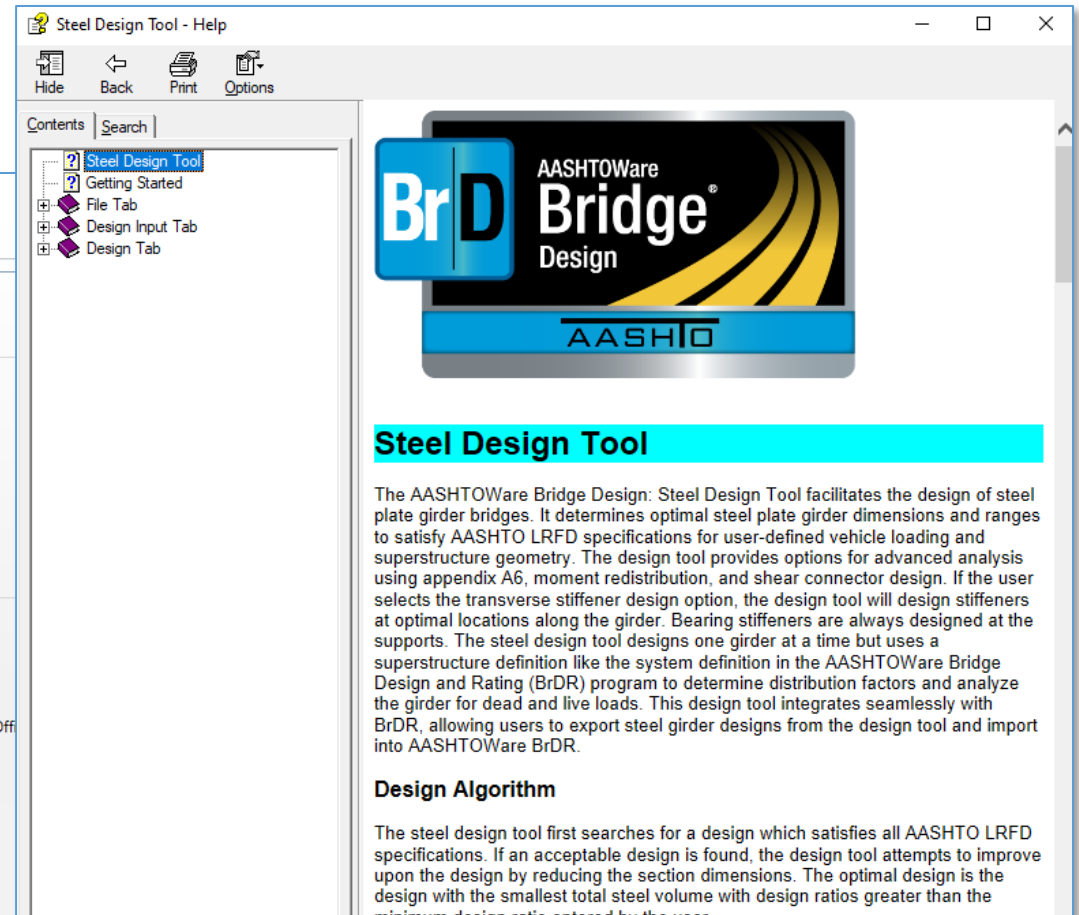
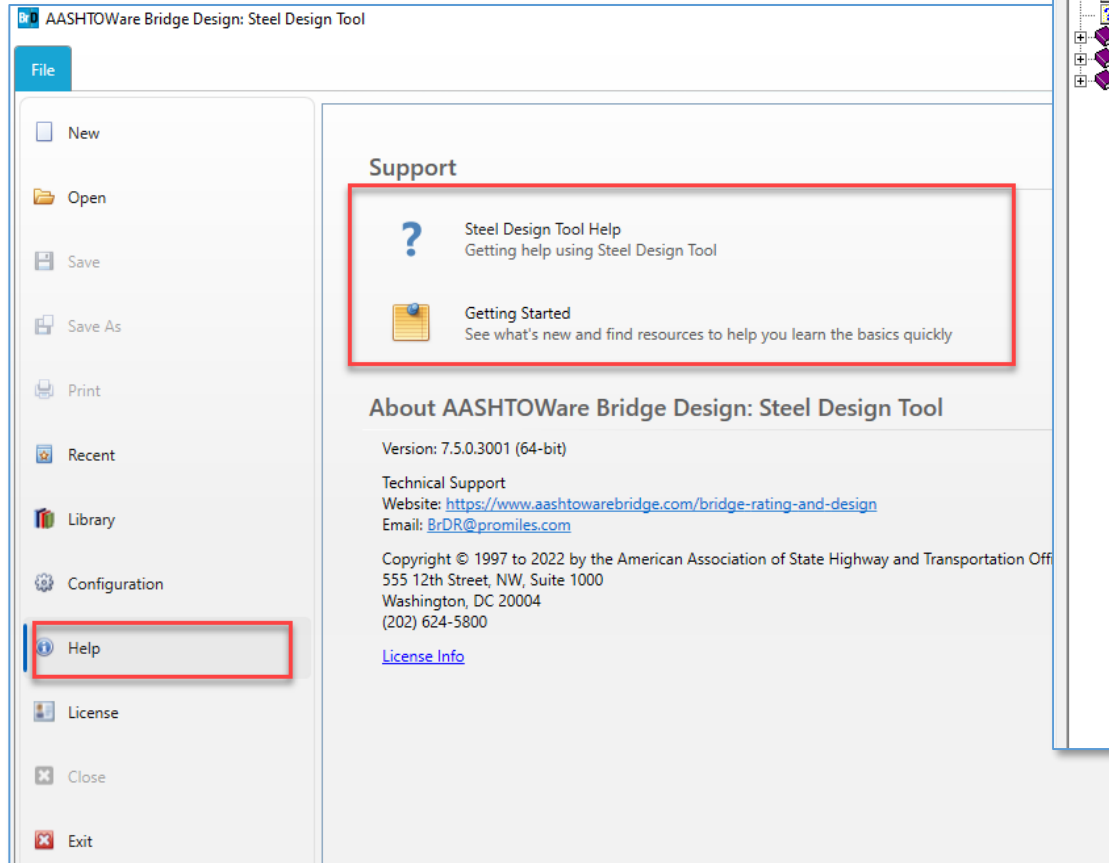
Bridge ID :  
 Bridge :  
 Superstructure Def : Steel Design Tool Example 1  
 Member : G1  
 Analysis Preference Setting : NA

AASHTO LRFD Specification, Edition 9, Interim 0

### Specification Check Summary

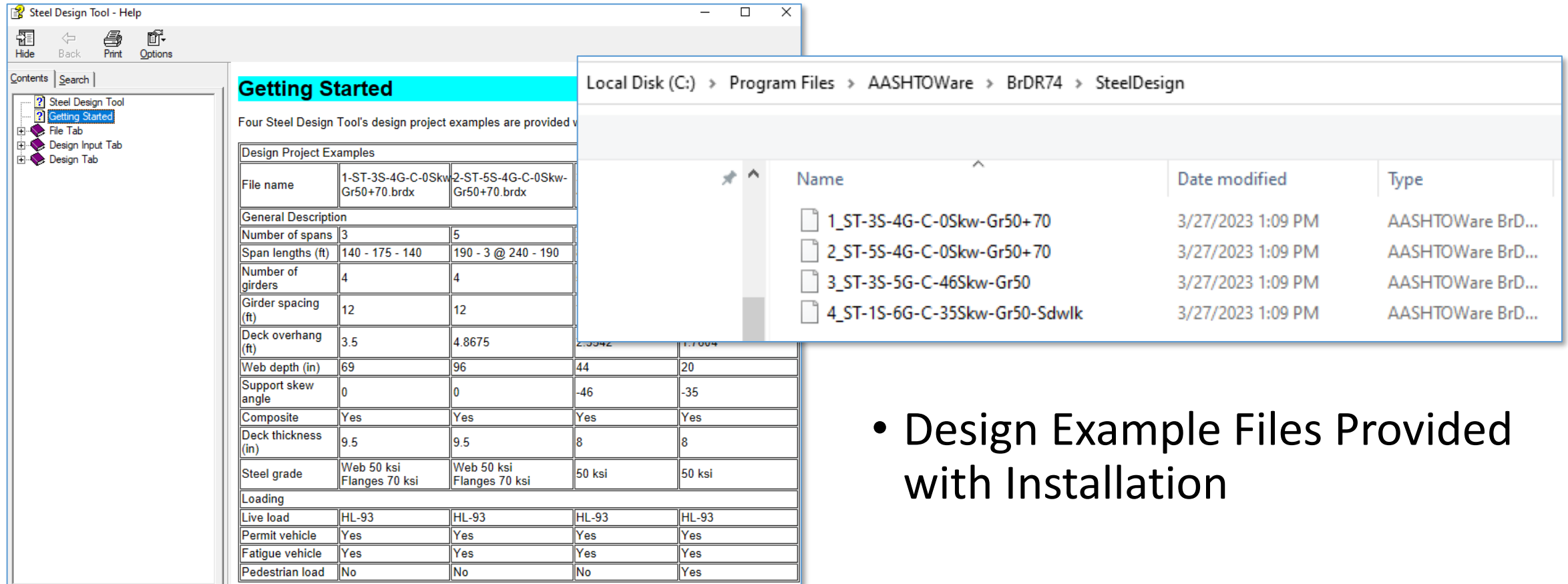
Article	Status
Flexure (6.10.7.1.1, 6.10.7.2.1, 6.10.8.1.1, 6.10.8.1.1, 6.10.8.1.1)	Pass
Shear (6.10.9)	Pass
Fatigue (6.10.5.3, 6.6.1.2.2)	Pass
Serviceability (6.10.4.2.2)	Pass
Constructability (6.10.3.2.1, 6.10.3.2.2, 6.10.3.2.3)	Pass
Transverse Stiffeners (6.10.11.1.2, 6.10.11.1.3)	Pass
Longitudinal Stiffeners (6.10.11.3.1, 6.10.11.3.2, 6.10.11.3.3)	NA
Bearing Stiffeners (6.10.11.2.2, 6.10.11.2.3, 6.10.11.2.4)	Fail
Shear Connector (6.10.10.1, 6.10.10.4)	NA
Field Splice (6.13.2.6, 6.13.2.7, 6.13.5.3, 6.13.6.1.3a, 6.13.6.1.3b, 6.13.6.1.3c)	NA
Minimum Negative Flexure Concrete Deck Reinforcement (6.10.1.7)	Pass
Deflection (2.5.2.6.2)	Pass

## Additional Information



- Help and Methodology

## Additional Information



The screenshot displays the Steel Design Tool interface. On the left, a 'Contents' pane lists sections like 'Getting Started', 'File Tab', 'Design Input Tab', and 'Design Tab'. The main window shows a 'Getting Started' section with a table of design project examples. A file explorer window is overlaid on the right, showing the path 'Local Disk (C:) > Program Files > AASHTOWare > BrDR74 > SteelDesign' and a list of four example files.

Design Project Examples	
File name	2-ST-5S-4G-C-0Skw-Gr50+70.brdx
General Description	
Number of spans	3
Span lengths (ft)	140 - 175 - 140
Number of girders	4
Girder spacing (ft)	12
Deck overhang (ft)	3.5
Web depth (in)	69
Support skew angle	0
Composite	Yes
Deck thickness (in)	9.5
Steel grade	Web 50 ksi Flanges 70 ksi
Loading	
Live load	HL-93
Permit vehicle	Yes
Fatigue vehicle	Yes
Pedestrian load	No

Name	Date modified	Type
1_ST-3S-4G-C-0Skw-Gr50+70	3/27/2023 1:09 PM	AASHTOWare BrD...
2_ST-5S-4G-C-0Skw-Gr50+70	3/27/2023 1:09 PM	AASHTOWare BrD...
3_ST-3S-5G-C-46Skw-Gr50	3/27/2023 1:09 PM	AASHTOWare BrD...
4_ST-1S-6G-C-35Skw-Gr50-Sdwlk	3/27/2023 1:09 PM	AASHTOWare BrD...

- Design Example Files Provided with Installation

# Future Enhancements and Integration

- Performed a gap analysis to identify areas for potential enhancement
- Work with the Design TAG to plan integration into BrD and evaluate and prioritize enhancements



# Future Enhancements and Integration

- Anticipated Enhancements in the following areas:
  - Design Algorithm
    - More variability in geometry and design input, and additional options on design optimization
  - Schematics
    - Additional graphics and schematics
  - Design Results
    - Additional design results for splices, diaphragms, bearings
  - Staged Construction and Constructability
    - Advanced evaluation of temporary stresses, staged construction, deck pour sequencing



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# Questions?

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Thank you!