



Photo: 2020 Prize Bridge National Winner, Major Span – Gov Cuomo/Tappen Zee (New York) – Photo Credit: New York State Thruway Authority

## Medium/Long Span Bridge Design - LRFD Simon

Devin Altman, PE – Bridge Steel Specialist (Steel Solutions Center)

Steel Bridge Essentials: Designing Cost Effective & Resilient Bridges



Smarter.  
Stronger.  
Steel.

# Devin Altman (Steel Solutions Center)

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- Bridge Steel Specialist in the Steel Solutions Center (SSC) for the NSBA, a division of the AISC. He represents the steel bridge industry on matters of steel bridge design, fabrication and construction. Devin's role with NSBA is to provide technical assistance, tools, and resources for steel bridge owners, designers, fabricators, university programs, and technical committees.
- 17 years of bridge industry experience, spent over 15 years in the bridge consulting profession as a bridge engineer and project manager, with 12 years at CH2M Hill/Jacobs working on a wide range of projects including design, load ratings, rehabilitation, complex analysis, and construction of a wide variety of structure types located throughout the USA and Internationally.
- B.S. in Mathematics from The Evergreen State College
- Master of Engineering degree in Structural Engineering and Construction Engineering Management from Oregon State University
- Registered Professional Engineer in Oregon



Smarter.  
Stronger.  
Steel.

# Learning Objectives

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- Understand how to develop the required inputs for LRFD Simon and your bridge
- Learn how to use the LRFD Simon User's Guide for further clarification when needed
- Understand how to interpret LRFD Simon output and increase resistance if needed
- Learn about LRFD Simon in general and when it is appropriate for design/analysis and when it is not
- Understand how to use NSBA Continuous Span Standards as a starting point

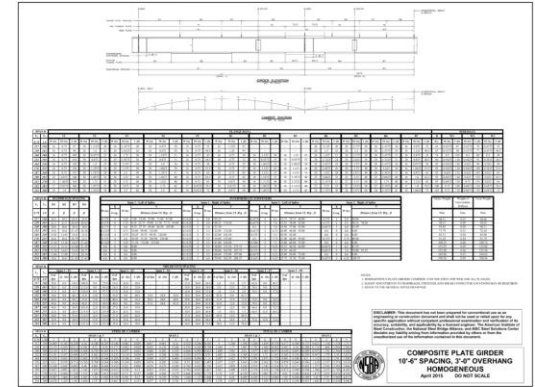


# Overview of the Design Tools Used Today

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## Continuous Span Standards

- Example steel girder design drawing detail/spec
- 5 girder bridge cross-sections with balanced design
- Per AASHTO LRFD BDS 7<sup>th</sup> Edition (update out soon)



## LRFD Simon

- Line girder analysis software
- Design mode, analysis mode, web depth optimization
- Per AASHTO LRFD BDS 9<sup>th</sup> Edition





# Where Can I Find These Free Design Tools

<https://www.aisc.org/nsba>

The image shows two browser screenshots of the National Steel Bridge Alliance (NSBA) website. The left screenshot shows the main homepage with a navigation menu where 'DESIGN AND ESTIMATING' is highlighted with a red box. A yellow arrow points from this box to the right screenshot, which shows the 'Design and Estimating' sub-page. On this page, a red box highlights the 'Design Resources and Software' section, which contains a link to 'Design Resources and Software' and a 'VIEW MORE' button. Other visible sections include 'Steel Span to Weight Curves', 'Steel Bridge Design Workshop', 'AASHTO/NSBA Collaboration Documents', 'Technical Resources and Research', and 'Steel Bridge Design Handbook'.

# Continuous Span Standards

- **Assist Engineers During the TS&L Phase:**

- LRFD Simon input files included
- Flange plate sizes and lengths
- Web plate sizes and lengths
- Diaphragm spacing
- Stiffener locations
- Girder weights
- Shear connector spacing
- Camber tables

NSBA National  
Steel Girder Standards  
(Available in Early 2023)

National Steel Bridge Alliance  
**Continuous Span Standard Solutions**



From first cut... ...to final concept.

- We've taken the iteration work out of selecting preliminary girder sizes.
- Save time during the TS&L project phase.
- Rapid comparison of cost effective solutions.

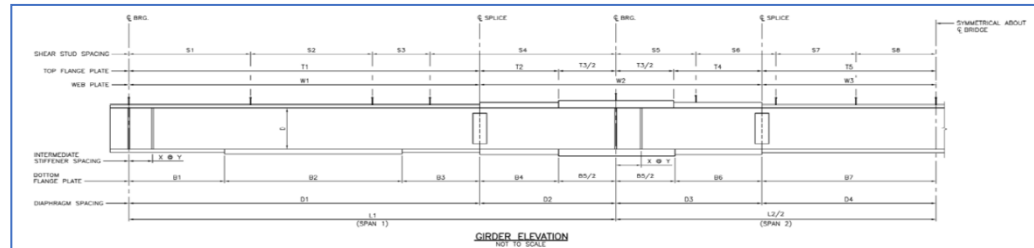
The National Steel Bridge Alliance (NSBA), a division of the American Institute of Steel Construction (AISC), is dedicated to advancing the state-of-the-art of steel bridge design and construction.

The national, non-profit organization is a unified voice representing the entire steel bridge community bringing together the agencies and groups who have a stake in the success of steel bridge construction.



There's always a bridge solution in steel.

National Steel Bridge Alliance  
One E. Wacker Drive, Suite 700  
Chicago, Illinois 60601-1827  
312.670.2400 | www.steelbridges.org



# Continuous Span Standards

## Preliminary designs include:

- Center Span: 150 ft – 300 ft
- End Spans: 78% of center span
- Girder Spacing: 7ft – 6in to 12ft – 0in
- Homogeneous and hybrid solutions
- Web depth to suite material efficiency
- AASHTO 7<sup>th</sup> Edition LRFD
- 88 Unique Solutions

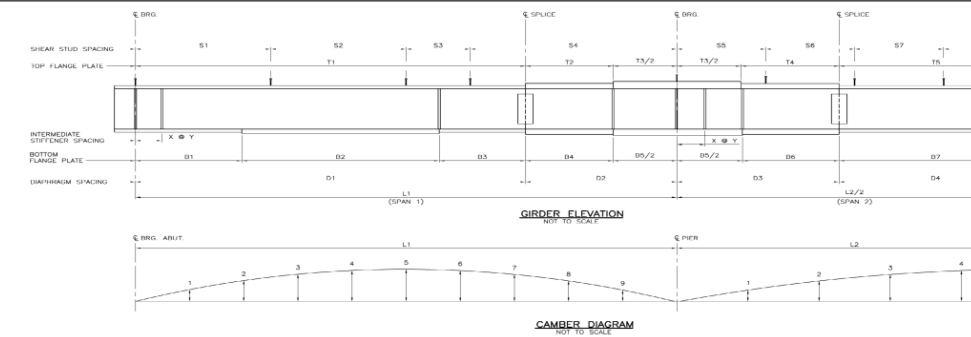


PLATE GIRDER SIZE																																	
T2			T3			T4			T5			B1			B2			B4			B5			B6			B7						
L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)	L (ft)	W (in)	Tb (in)				
87	18	0.875	20	20	1.125	20	18	0.875	30	16	0.75	35	20	0.875	37	-	-	-	20	1.25	20	20	1.25	20	18	1.5	30	16	0.8125				
94	18	1.0625	22	20	1.0625	26	18	1.25	29	16	0.75	40.5	16	1.0	34	-	-	-	18	1.625	22	20	2.375	26	18	1.5625	20	16	0.875	4			
105	18	0.75	21	20	1.375	28	18	1.625	31	16	0.75	45	16	0.75	30	18	0.8125	50	18	0.75	25	20	1.125	21	20	2.28	18	2.125	31	18	0.75	4	
110	18	0.8125	24	20	1.5625	36	18	0.75	31	16	0.75	48.5	16	0.75	32	18	0.8125	53	18	0.8125	25	20	1.1875	24	22	2.25	36	20	1.25	31	16	0.75	4
20	18	1.0625	25	20	2.125	38	18	1.625	36	16	0.75	50	16	0.75	35	18	0.8125	55	18	0.8125	30	1.3125	25	22	2.0	38	20	2.125	36	16	0.75	4	
18	1.375	26	20	2.375	40	18	1.1875	39	16	0.75	53.5	16	0.75	37	18	0.9375	45	18	0.9375	28	20	1.5	26	22	2.25	40	1.5	30	16	0.9375	5		
18	1.4375	28	20	2.625	48	18	1.25	31	16	0.75	65	16	0.75	45	18	1.0625	55	18	1.0625	35	20	1.6875	28	22	2.5	48	20	1.5	31	16	0.875	6	
18	1.5625	35	20	2.75	48	18	1.5	40	16	0.75	63.5	16	0.875	45	18	1.125	55	18	1.125	40	20	1.8125	35	22	2.75	48	20	1.75	40	16	0.75	6	
18	1.5	31	20	2.875	60	18	1.25	40	16	0.75	65	16	0.75	50	18	1.125	60	18	1.125	40	20	1.6875	31	22	2.875	60	20	1.4375	40	16	1.0625		
18	1.5625	33	20	2.875	58	18	1.4375	43	17	0.8125	70.5	17	0.75	50	18	1.0	70	18	1.0	40	20	1.8125	33	22	2.875	58	20	1.75	43	17	0.875		
20	2.5	30	24	2.625	68	22	1.125	41	18	0.8125	75	20	0.9375	50	20	1.0625	75	22	1.0625	45	22	3.25	30	22	3.125	68	22	1.625	41	18	0.75		

INTERMEDIATE STIFFENERS															
Span 1 - Left of Splice				Span 1 - Right of Splice				Span 2 - Left of Splice				Span 2 - Right of Splice			
Tb (in)	# req.	W (in)	Distance from CL Brq - ft	Tb (in)	# req.	W (in)	Distance from CL Brq - ft	Tb (in)	# req.	W (in)	Distance from CL Brq - ft	Tb (in)	# req.	W (in)	Distance from CL Brq - ft
0.0	0	0.0	0.00	0.0	0	0.0	0.00	0.3	2	5.0	12.5 25.0	0.0	0	0.0	0.00
0.0	0	0.0	0.00	0.313	1	5.0	116.00	0.313	1	5.0	13.00	0.0	0	0.0	0.00
0.0	0	0.0	0.00	0.313	2	5.0	106.00 123.00	0.375	2	5.0	17.00 44.00	0.0	0	0.0	0.00
0.313	1	4.5	8.75	0.313	2	5.5	117.00 134.50	0.375	2	5.75	17.50 35.00 40.00	0.0	0	0.0	0.00
0.313	3	4.5	9.00 102.00 130.00	0.313	2	5.5	128.00 146.00	0.438	3	6.25	18.00 50.00 54.00	0.0	0	0.0	0.00
313	4	4.5	9.00 27.00 112.00 130.00	0.313	2	5.5	140.00 158.00	0.438	4	6.5	18.00 36.00 54.00 59.00	0.0	0	0.0	0.00
75	4	5.0	22.5 27.5 116.50 135.00	0.313	2	5.5	150.00 168.50	0.375	2	5.75	18.50 37.00	0.375	2	6.0	55.00 73.50
0.0	0	0.0	0.00	0.313	2	5.5	156.00 177.50	0.375	2	5.5	21.50 43.00	0.0	0	0.0	0.00
0.0	0	0.0	0.00	0.313	2	5.5	165.50 188.25	0.313	3	5.5	22.75 45 68.25	0.0	0	0.0	0.00
0.0	0	0.0	0.00	0.313	2	5.5	172.00 197.00	0.438	2	7.0	25.00 50.00	0.0	0	0.0	0.00
0.0	0	0.0	0.00	0.313	2	6.0	182.50 208.25	0.438	2	6.75	25.75 51.50	0.0	0	0.0	0.00

SHEAR CONNECTION SPACING																									
Span 1 - S3						Span 2 - S6						Span 2 - S7						Span 2 - S8							
W (in)	# of Spa	W (in)	L (ft)	# of Spa	W (in)	L (ft)	# of Spa	W (in)	L (ft)	# of Spa	W (in)	L (ft)	# of Spa	W (in)	L (ft)	# of Spa	W (in)	L (ft)	# of Spa	W (in)	L (ft)	# of Spa	W (in)	L (ft)	
12.0	15.0	24.0	30.0	14.0	24.0	30.0	8.0	12.0	8.0	30.0	12.0	30.0	-	-	-	-	-	-	-	-	-	-	-	-	-
13.5	16.0	24.0	32.0	15.0	24.0	30.0	9.0	12.0	9.0	34.0	12.0	35.0	18.0	12.0	18.0	-	-	-	-	-	-	-	-	-	-
0	17.0	24.0	34.0	17.0	24.0	34.0	56.0	12.0	56.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0	19.0	24.0	38.0	18.0	24.0	36.0	10.0	15.0	12.5	40.0	12.0	49.0	-	-	-	-	-	-	-	-	-	-	-	-	-
0	20.0	24.0	40.0	20.0	24.0	40.0	6.0	18.0	0.0	50.0	12.0	56.0	-	-	-	-	-	-	-	-	-	-	-	-	-
0	24.0	42.0	22.0	24.0	44.0	9.0	15.0	11.25	46.0	12.0	46.0	15.0	9.0	11.3	-	-	-	-	-	-	-	-	-	-	-
0	25.0	24.0	48.0	37.0	12.0	37.0	20.0	15.0	25.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0	26.0	24.0	50.0	44.0	15.0	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	62.0	25.0	24.0	50.0	12.0	15.0	15.0	45.0	12.0	45.0	20.0	15.0	25.0	-	-	-	-	-	-	-	-	-	-	-	-
0	35.0	24.0	70.0	58.0	15.0	72.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0	68.0	36.0	24.0	72.0	52.0	18.0	78.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TOTAL DL CAMBER														
SPAN 1 & 3						SPAN 2								
1	2	3	4	5	6	7	8	9	1	2	3			
0.471	0.308	1.403	1.812	1.947	1.81	1.446	0.946	0.444	0.085	0.337	1.035	1.84	2.469	2.703
1.048	1.912	2.465	2.645	2.456	1.964	1.304	0.657	0.188	0.779	1.010	1.903	2.626	2.906	0.863
0.863	1.719	2.216	2.316	1.908	1.577	1.013	0.455	0.075	0.383	0.881	1.868	2.489	2.722	0.202
2.001	2.569	2.752	2.555	2.044	1.349	0.666	0.174	0.331	1.183	2.215	3.025	3.331	2.439	0.249
2.439	3.119	3.324	3.062	2.422	1.575	0.737	0.191	0.414	1.337	2.432	3.332	3.671	2.819	0.289
3.189	3.712	4.152	3.715	2.862	1.811	0.758	0.16	0.463	1.621	2.843	3.963	4.406	3.428	0.336
4.428	4.684	4.287	3.370	2.183	1.055	0.281	0.509	1.730	3.325	4.647	5.153	5.575	4.428	0.376
3.776	4.033	3.715	2.955	1.946	1.073	0.278	0.404	1.527	3.24	4.186	4.747	5.189	4.077	0.407
4.287	3.811	3.667	2.813	1.609	0.289	0.538	1.521	2.619	3.669	4.697	5.153	5.575	4.428	0.407
3.916	3.603	2.849	1.859	0.912	0.248	0.415	1.424	2.711	3.773	4.175	4.428	4.747	3.603	0.407
4.078	3.263	2.197	1.163	0.36	0.409	1.536	1.624	4.262	4.732	5.153	5.575	5.997	4.428	0.407

NOTES:  
 1. HOMOGENEOUS PLATE GIRDERS COMBINED  
 2. SLIGHT ADJUSTMENTS TO DIAPHRAGM ST. TO MAINTAIN CENTER LINE  
 3. REFER TO THE GENERAL NOTES DRAWING

This document has not been prepared for construction document and shop application without customer approval. Accuracy, suitability, and applicability of Steel Construction, the National Center disclaim any liability arising from unauthorized use of the information.



COMP 7'-6" SP

# LRFD Simon

**Named After Singer/Songwriter Paul Simon (Bridge over Troubled Water)**

- Originally Developed in the Late 1960's by U.S. Steel Corporation in Cooperation with Wisconsin Department of Transportation
- Late 2021 Release Satisfies AASHTO LRFD BDS 9<sup>th</sup> Edition
- Design Run Option
- Analysis Mode
- Free Software
- NSBA & AISC Support





# LRFD Simon

## Analysis and Design Program

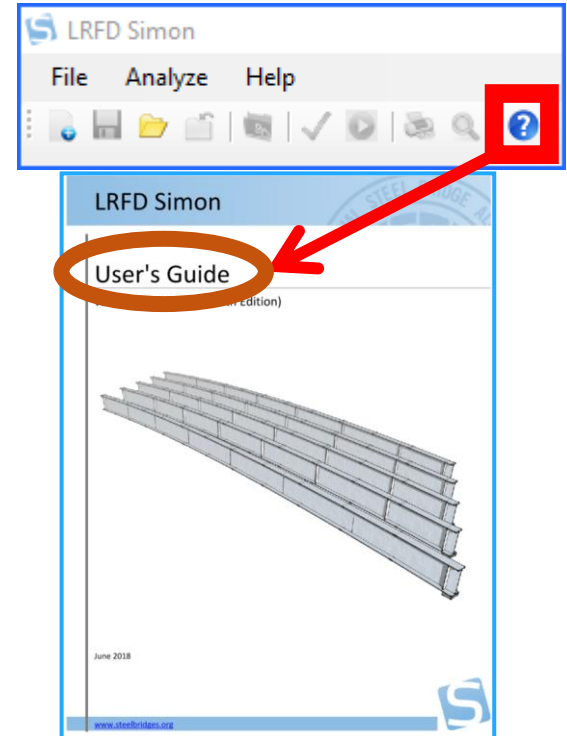
- Powerful Line-Girder Analysis & Design Software
- I-Girder and Box Girders Bridges
- Linear and Parabolic Haunches
- AASHTO LRFD Bridge Design Specification – 9<sup>th</sup> Edition
- Straight Bridges with Minimal Skew (i.e. equal to or less than 20 deg.)
- Help Develop Cost Estimates with Tabulated Quantities in Report



# LRFD Simon

## Analysis and Design Program

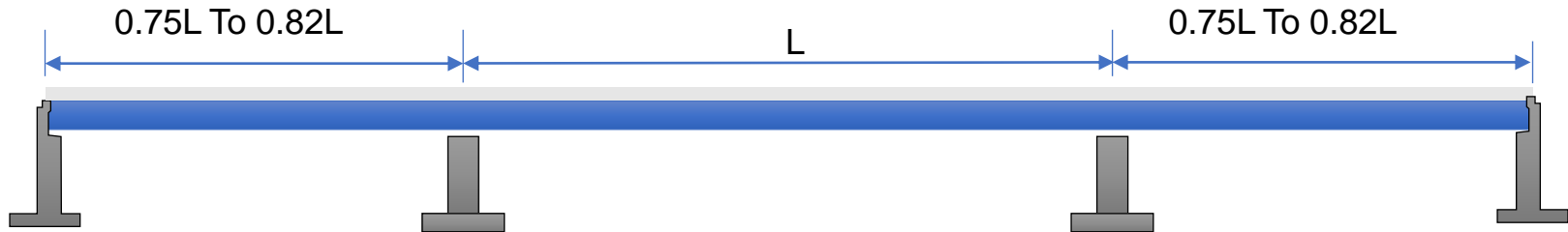
- Independently Design One Solution for both Interior and Exterior Girders
- Analyze both Interior and Exterior Girders
- Capable of Modeling Various Bridge Geometries and Design Loading Configurations
- Generates Service and Strength Moments, Shears, Deflections, and Bearing Reactions
- Helpful User's Guide Manual Written by Mike Grubb & Associates



# Keep in Mind Before We Get Started

## Span Layouts

- Try to layout span arrangements with maximum positive moments being nearly equal in each span
- End spans ideally 75% - 82% of center span

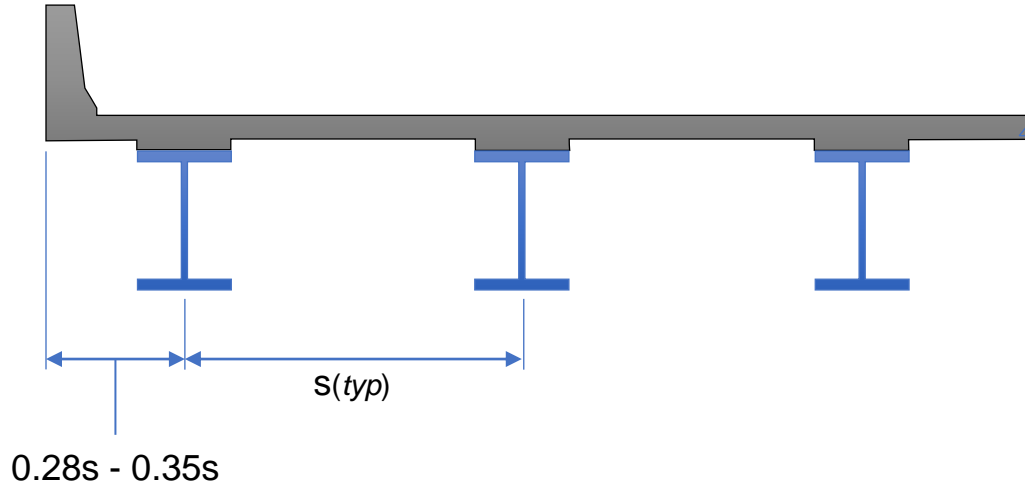


Balanced Span Arrangement

# Keep in Mind Before We Get Started

## Girder Spacing & Deck Overhangs

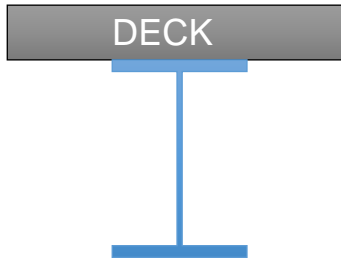
- Total factored moment tends to be larger in exterior girders (subject to lateral bridge deck overhang truck impact loads)
- Limit size of deck overhangs accordingly



# Keep in Mind Before We Get Started

## Proportioning – Web Depth

- Optional Span-to-Depth Ratio (AASHTO BDS Section 2.5.2.6.3)



Simple Spans	0.040L
Continuous spans	0.032L

### Suggested Minimum Overall Depth for Composite I-beam



Simple Spans	0.033L
Continuous spans	0.027L

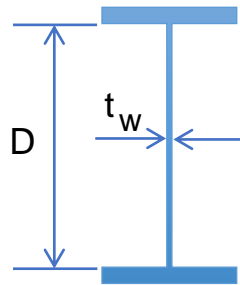
### Suggested Minimum Depth for I-beam



# Keep in Mind Before We Get Started

## Proportioning – Web Thickness

- Web Thickness (AASHTO BDS Section 6.10.2.1)



Without Longitudinal Stiffeners	$\frac{D}{t_w} \leq 150$
With Longitudinal Stiffeners	$\frac{D}{t_w} \leq 300$

- ½" minimum thickness preferred by fabricators

# Keep in Mind Before We Get Started

## Proportioning - Flanges

- Proportioning Requirements (AASHTO BDS Section 6.10.2.2):

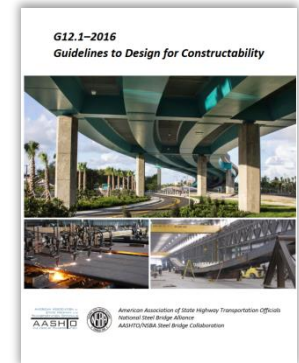
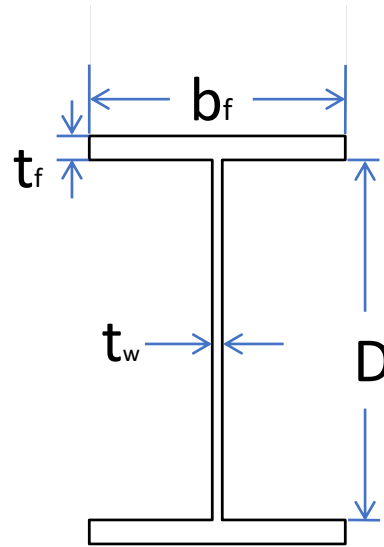
$$\frac{b_f}{2t_f} \leq 12$$

$$b_f \geq \frac{D}{6}$$

$$t_f \geq 1.1 t_w$$

$$0.1 \leq \frac{I_{yc}}{I_{yt}} \leq 10$$

Fabricators prefer:  $b_f \geq 12$  in.;  $t_f \geq 0.75$  in.



# Keep in Mind Before We Get Started

## Field-Section Lengths for Steel I-Girders

- Shipment by truck is the most common means
  - 215 ft. Possible, 80 ft. Comfortable, 80 – 150' typical
  - Over 100 Tons Possible (20 Tons - No Permit)
  - 16 ft. Width and 10 ft. Height (depending on truck and route)
  - Girder under 9' deep can usually be shipped vertical to anywhere



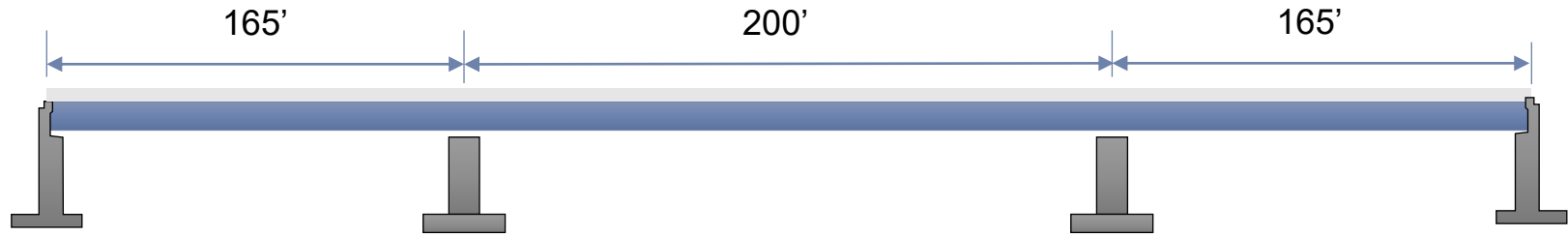
LRFD SIMON



# 3-Span Continuous Example

# What if Your Span Layout is This?

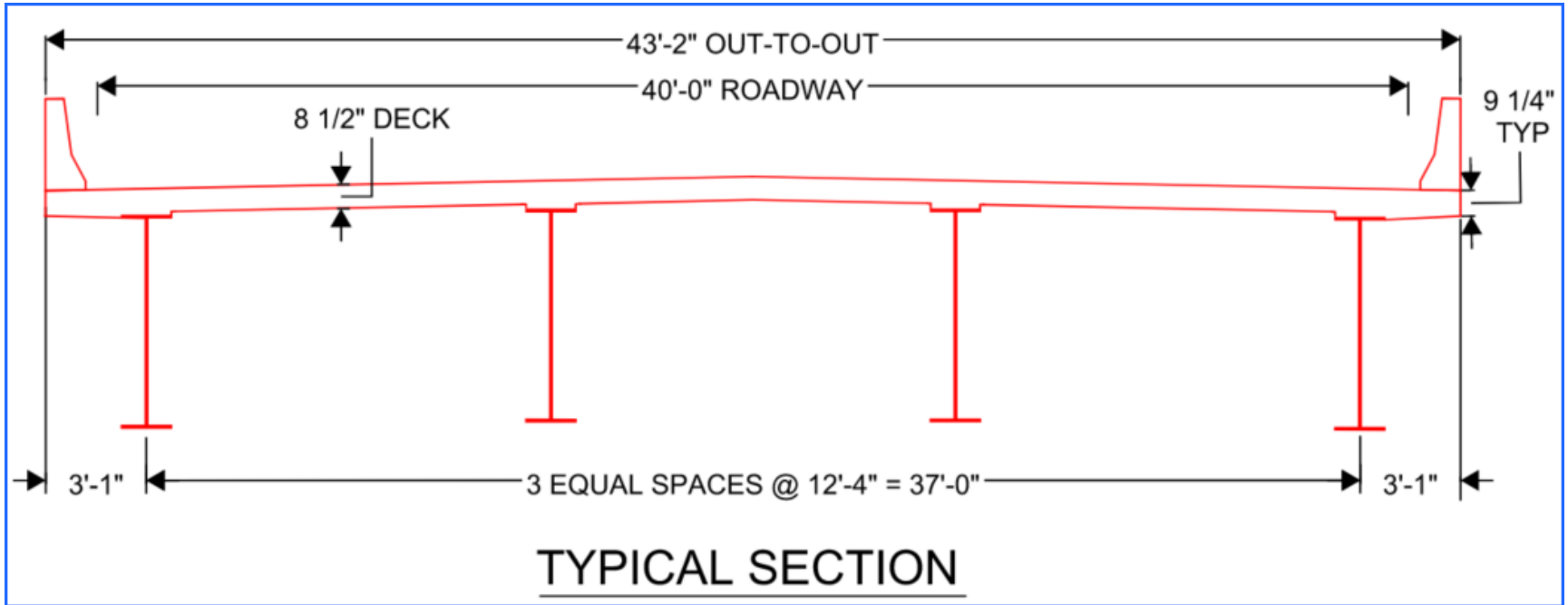
The Continuous Span Standards Come with LRFD Simon Inputs





# What if Your Cross-Section is This?

The Continuous Span Standards Come with LRFD Simon Inputs



# Everything is Different Should I Start Over?

## No, But We Still Need to Do the Hard Work and Develop the Design

- Generate Load Demands
- Compare Continuous Span Standards Loading Assumptions with Project
- Does Superstructure Depth Work for Project Constraints
- Overhang: Girder Spacing = 0.25 (Lower than Ideal)
- Verify and Check Everything (Assume it is All Wrong)

### Continuous Span Standards

The Continuous Span Standards serve as a guide to state, county, and local highway departments in the development of suitable and economical steel bridge superstructures. Included are 88 unique solutions for three-span bridges with center spans between 150'-0" and 300'-0", girder spacings between 7'-6" and 12'-0", and plate girder designs utilizing both homogenous and hybrid steel options. These solutions were developed using the latest version of the AISC/NSBA LRFD Simon software v10.2 with the input files provided as part of the download.



The Simon input files were provided because the NSBA understands bridge span arrangements almost never match an idealized solution (ends span lengths at 78% of center span length). In providing the files, the NSBA has integrated two of its most successful resources into one powerful preliminary design tool. Find a span arrangement that most closely matches the bridge's geometry and begin editing from that file. This saves time and allows for more exploration of girder depths and steel strength options.

Included on each conceptual solution are tables presenting girder plate sizes, diaphragm spacings, intermediate stiffener sizes and locations, shear connector spacings, camber, and girder weights.

[DOWNLOAD THE CONTINUOUS SPAN STANDARDS](#)

# Grab LRFD Simon File Similar to Your Bridge

Our Girder Material is ASTM A709 50W, Homogeneous (Not Hybrid)

The image shows a sequence of three screenshots from a Windows File Explorer window, illustrating the navigation path to a specific file. The top screenshot shows the root folder 'continuous-span-standards' with 'Simon Input Files' selected. The middle screenshot shows the 'Simon Input Files' folder with 'Homogeneous' selected. The bottom screenshot shows the 'Homogeneous' folder with '12.0 Spacing' selected. To the right, a list of files is shown, with 'EXTERIOR - 164ft - 210ft - 164ft spacing 12\_0ft oh 3\_5ft.dat' highlighted in green.

**Navigation Path:**  
This PC > Documents > SIMON > continuous-span-standards > Simon Input Files > Homogeneous > 12.0 Spacing

**File List:**

Name	Date modified	Type	Size
Simon Input Files	5/20/2020 9:27 AM	File folder	
NSBAContinuousSpanStandards.pdf	5/20/2020 9:27 AM	PDF Document	517 KB
NSBAContinuousSpanStandards_README.pdf	5/20/2020 9:27 AM	PDF Document	11 KB

Name	Date modified
Homogeneous	5/20/2020 9:27 AM
Hybrid	5/20/2020 9:27 AM

Name	Date modified
7.5 Spacing	5/20/2020 9:27 AM
9.0 Spacing	5/20/2020 9:27 AM
10.5 Spacing	5/20/2020 9:27 AM
12.0 Spacing	5/20/2020 9:27 AM

EXTERIOR - 129ft - 165ft - 129ft Spacing 12_0ft oh 3_5ft.dat
EXTERIOR - 140ft - 180ft - 140ft Spacing 12_0ft oh 3_5ft.dat
EXTERIOR - 152ft - 195ft - 152ft spacing 12_0ft oh 3_5ft.dat
EXTERIOR - 164ft - 210ft - 164ft spacing 12_0ft oh 3_5ft.dat
EXTERIOR - 187ft - 240ft - 187ft spacing 12_0ft oh 3_5ft.dat
EXTERIOR - 222ft - 285ft - 222ft spacing 12_0ft oh 3_5ft.dat
EXTERIOR - 234ft - 300ft - 234ft spacing 12_0ft oh 3_5ft.dat
INTERIOR - 117ft - 150ft - 117ft spacing 12_0ft oh 3_5ft.dat
INTERIOR - 176ft - 225ft - 176ft spacing 12_0ft oh 3_5ft.dat
INTERIOR - 199ft - 255ft - 199ft spacing 12_0ft oh 3_5ft.dat
INTERIOR - 211ft - 270ft - 211ft spacing 12_0ft oh 3_5ft.dat

# Design Girders with Project Design Criteria

## I Recommend Using Excel or MathCAD Spreadsheet for Girder Design

SIMON inputs (General Properties)			
Superstructure Type	I-Girder		
Number of Spans	1		
Number of Girders	4		
Roadway Width	40.00	ft	
Number of Lanes	3		
Run Option	LRFD Analysis		
Redesign Performance Ratio	0.900		
Maximum Performance Ratio	1.000		
Minimum Flange Thickness	0.75	in	
Maximum Plate Thickness	3	in	
Distance From Bottom of Slab to cg Rebar	3.6875	in	
Distance From Bottom of Slab to Top of Web	3	in	
ADTT (Single Lane)	800	trucks/day	
Fatigue Service Life	75	years	

EXTERIOR - 164ft - 210ft - 164ft spacing 12\_0ft oh 3\_5ft.dat - LRFDSimon

File Analyze Help

- LRFD Simon
  - Model
    - General Properties
    - Distribution Factors
    - Material Properties
    - Loads
    - User Defined Design Vehicle Properties
    - Transverse Stiffener Properties
    - Shear Stud Properties
    - Span Information
      - Span 1
      - Span 2
      - Span 3
    - Cross Section
      - Span 1
      - Span 2
      - Span 3 (symmetrical)
    - Costs
      - Material
      - Fabrication
      - Web Depth Optimization
    - Result Controls
    - Results

Comments, line 1: EXTERIOR - Spacing 12\_0 ft - 3\_5 ft Overhang

Comments, line 2: LRFD, COMPOSITE (POS. BENDING ONLY), HL93 LOADING

Comments, line 3: THREE SPANS (164'-210'-164'), FIVE GIRDERS

Beam type: I-Girder

Number of spans: 3

Number of girders: 5

Number of traffic lanes: 4

Run option: LRFD Analysis

Redesign performance ratio: 0.9

Maximum performance ratio: 1.02

Minimum flange thickness: 0.75 in

Maximum plate thickness: 4.0 in

Distance from slab bottom to cg of reinforcement: 4.5 in

Distance from slab bottom to web top: 3.0 in

Average daily truck traffic, single lane: 1500

Fatigue service life: 75 years

# General Properties – Exterior Girder

## Vet & Update LRFD Simon Inputs for Project Requirements

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

LRFD Simon

- Model
  - General Properties**
  - Distribution Factors
- Material Properties
- Loads
- User Defined Design Vehicle Properties
- Transverse Stiffener Properties
- Shear Stud Properties
- Span Information
  - Span 1
  - Span 2
  - Span 3
- Cross Section
  - Span 1
  - Span 2
  - Span 3 (symmetrical)
- Costs
  - Material
  - Fabrication
- Web Depth Optimization
- Result Controls
- Results

Comments, line 1: EXTERIOR - Spacing 12.333 ft - 3' - 1" Overhangs

Comments, line 2: AASHTO LRFD BDS, COMPOSITE, HL93 LOADING

Comments, line 3: 3-Span-Continuous (165'-200'-165'), Four Girders

Beam type: I-Girder

Number of spans: 3

Number of girders: 4

Number of traffic lanes: 3

Run option: LRFD Analysis

Redesign performance ratio: 0.9

Maximum performance ratio: 1.0

Minimum flange thickness: 0.75 in

Maximum plate thickness: 3.0 in

Distance from slab bottom to cg of reinforcement: 4.02 in

Distance from slab bottom to web top: 4 in

Average daily truck traffic, single lane: 800

Fatigue service life: 75 years

Bridge Layout

Run Type

Design Parameters and Boundaries

Deck Properties

Fatigue Parameters



# Distribution Factors – Exterior Girder

## Vet & Update LRFD Simon Inputs for Project Requirements

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFD Simon

File Analyze Help

LRFD Simon

- Model
  - General Properties
  - Distribution Factors**
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
- Span Information
  - Span 1
  - Span 2
  - Span 3
- Cross Section
  - Span 1
  - Span 2
  - Span 3 (symmetrical)
- Costs
  - Material
  - Fabrication
  - Web Depth Optimization
  - Result Controls
- Results

Distribution factor definition: User Defined

Computed Distribution Factors

- Girder skew: 0 degrees
- Girder spacing: 12.333 ft
- Distance from web to curb, de: 1.583 ft
- Girder location: Exterior

User Input Moment Distribution Factors

- Single lane: 0.858
- Multiple lane: 0.938

User Input Shear Distribution Factors

- Single lane: 0.858
- Multiple lane: 0.938

User Defined or Program Defined

Calculated based on AASHTO BDS

Define Interior or Exterior

Calculated manually:

- $LLDF_{M\_SL} = 0.858$  lanes
- $LLDF_{M\_ML} = 0.938$  lanes
- $LLDF_{S\_SL} = 0.858$  lanes
- $LLDF_{S\_ML} = 0.938$  lanes

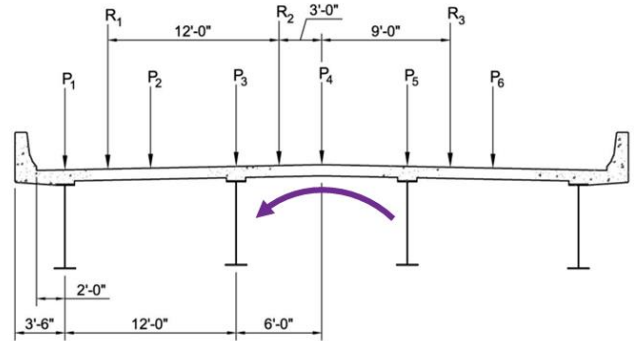
# Distribution Factors – Exterior Girder

## AASHTO LRFD BDS Special Analysis (C4.6.2.2.2d - Commentary)

- Assuming the entire cross-section rotates as a rigid body about the longitudinal centerline of the bridge, distribution factors for the exterior girder are also computed for one, two and three lanes loaded using the following formula

$$R = \frac{N_L}{N_b} + \frac{X_{ext} \sum e^{N_L}}{\sum x^2 N_b} \quad (\text{C4.6.2.2.2d-1})$$

- SIMON Now Computes this LLDF (Other Design Software May Not, Verify)



# Material Properties – Exterior Girder

## Vet & Update LRFD Simon Inputs for Project Requirements

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties**
  - Loads
    - User Defined Design Vehicle Properties
    - Transverse Stiffener Properties
    - Shear Stud Properties
  - Span Information
    - Span 1
    - Span 2
    - Span 3
  - Cross Section
    - Span 1
    - Span 2
    - Span 3 (symmetrical)
  - Costs
    - Material
    - Fabrication
    - Web Depth Optimization
    - Result Controls
  - Results

Modular ratio, n

Slab compressive strength  psi

Reinforcement yield strength  ksi

Longitudinal stiffener yield strength  ksi

Transverse and bearing stiffener yield strength  ksi

Concrete type

Steel surface condition

Connection plate type

Slab meet 6.10.1.7 criteria

Deck & Stiffener Material Properties

Other Miscellaneous Material Property Details

# Loads – Composite DL (Distribute Equal) & LL

## Vet & Update LRFD Simon Inputs for Project Requirements

The screenshot displays the LRFD Simon software interface for a project titled "EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFD Simon". The left-hand navigation pane shows a tree structure with "Loads" highlighted in a red box. The main workspace is divided into two sections:

- Uniform Dead Loads:** This section contains three input fields: "Composite" (264 lb/ft), "Utility" (0 lb/ft), and "Future wearing surface" (250 lb/ft). A green bracket on the right groups these three fields under the label "Composite Dead Loads (DC2 & DW)".
- Live Load Design Criteria:** This section contains several input fields: "Design vehicle option" (set to "HL93/User Defined Design Vehicle (envelope)"), "Live load deflection factor" (800.0), "Pedestrian live load" (0.0 lb/ft), and a "Dynamic Load Allowance" sub-section with "Design vehicle" (1.33) and "Fatigue vehicle" (1.15). A green bracket on the right groups these fields under the label "Live Load Design Criteria".

# User Defined Vehicle (None for Example)

Up to 40 Axles for Strength II Permit/Superloads/Emergency Vehicles

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFDSimon

File Analyze Help

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
    - User Defined Design Vehicle Properties**
    - Transverse Stiffener Properties
  - Shear Stud Properties
- Span Information
  - Span 1
  - Span 2
  - Span 3
- Cross Section
  - Span 1
  - Span 2
  - Span 3 (symmetrical)
- Costs
  - Material
  - Fabrication
- Web Depth Optimization
- Result Controls
- Results

Distribution factor type for truck

Distribution factor type for lane

Lane live load  kip / ft

Include all axles

	Axle Number	Axle Load, kips	Axle Spacing, ft
▶	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		



# Transverse Stiffener – Exterior Girder

## Vet & Update LRFD Simon Inputs for Project Requirements

The screenshot displays the LRFD Simon software interface. The title bar reads "EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFD Simon". The menu bar includes "File", "Analyze", and "Help". The left-hand navigation pane shows a tree structure with "LRFD Simon" at the top, followed by "Model" and its sub-items: "General Properties", "Distribution Factors", "Material Properties", "Loads", "User Defined Design Vehicle Properties", "Transverse Stiffener Properties" (highlighted with a red box), "Shear Stud Properties", "Span Information" (with sub-items "Span 1", "Span 2", "Span 3"), "Cross Section" (with sub-items "Span 1", "Span 2", "Span 3 (symmetrical)"), "Costs" (with sub-items "Material", "Fabrication", "Web Depth Optimization", "Result Controls"), and "Results".

The main workspace shows two input fields:

- "Maximum transverse stiffener spacing" with a text box containing "384" and "in" to its right. A green arrow points from the text "LRFD Simon Calculates if Left Blank" to the text box.
- "One sided transverse stiffeners" with a dropdown menu set to "Yes". A green arrow points from the text "1 or 2 Sided Transverse Stiffeners?" to the dropdown menu.

# Shear Studs – Exterior Girder

## Vet & Update LRFD Simon Inputs for Project Requirements

The screenshot displays the LRFD Simon software interface. The title bar reads "EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFD Simon". The menu bar includes "File", "Analyze", and "Help". The left-hand navigation pane shows a tree structure with "LRFD Simon" at the top, followed by "Model" and its sub-items: "General Properties", "Distribution Factors", "Material Properties", "Loads", "User Defined Design Vehicle Properties", "Transverse Stiffener Properties", "Shear Stud Properties" (highlighted with a red box), "Span Information" (with sub-items "Span 1", "Span 2", "Span 3"), "Cross Section" (with sub-items "Span 1", "Span 2", "Span 3 (symmetrical)"), "Costs" (with sub-items "Material", "Fabrication", "Web Depth Optimization", "Result Controls"), and "Results".

The main workspace shows the "Shear Connector Design" section with a dropdown menu set to "Yes". Below this are input fields for "Distance from interior support to nearest shear connector" (0.0 ft), "Concrete weight used to calculate concrete elastic modulus" (145 lb / ft<sup>3</sup>), and "Desirable pitch increment" (6 in). A "Stud Properties" section contains input fields for "Diameter" (0.875 in), "Length" (6 in), and "Studs per row" (2). A green bracket on the right side of the interface groups these input fields, pointing to a text box.

LRFD Simon Designs the Shear Studs for You, Define the Shear Stud Geometrics and Concrete Modulus of Elasticity Used for Design

# Span Information – Span 1

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFD Simon

File Analyze Help

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
  - Span Information
    - Span 1**
    - Span 2
    - Span 3
  - Cross Section
    - Span 1
    - Span 2
    - Span 3 (symmetrical)
  - Costs
    - Material
    - Fabrication
    - Web Depth Optimization
    - Result Controls
  - Results

Symmetrical span

Span length  ft

Hinge location\*  ft

Noncomposite uniform dead load  lb / ft

Noncomposite partial dead load, A1  lb / ft

Distance\* to end of A1 load  ft

Noncomposite partial dead load, A2  lb / ft

Distance\* to beginning of A2 load  ft

Bottom flange cross frame spacing  ft

Top flange fully braced for noncomposite loads

Noncomposite top flange cross frame spacing  ft

Top flange fully braced for final state

Final state top flange cross frame spacing  ft

Construction lateral moment  kip - ft

\*NOTE: Distances are measured from the left end of the current span

Span and Non-Composite Uniform Dead Load (DC1)

Bottom Flange Cross-Frame Spacing

Top Flange Bracing

Construction Lateral Moment Applied to Top & Bottom Flanges (Overhang)

# Span Information – Span 2

The screenshot displays the LRFD Simon software interface for configuring Span 2. The left sidebar shows a tree view with 'Span 2' highlighted in a red box. The main panel contains the following configuration options:

- Symmetrical span:
- Span length:  ft (Annotated with a green arrow and text: "Span 2 Length = 200 ft")
- Hinge location\*:  ft
- Noncomposite uniform dead load:  lb / ft
- Noncomposite partial dead load, A1:  lb / ft
- Distance\* to end of A1 load:  ft
- Noncomposite partial dead load, A2:  lb / ft
- Distance\* to beginning of A2 load:  ft
- Bottom flange cross frame spacing:  ft (Annotated with a green arrow and text: "Bottom Flange Cross-Frame Spacing (Negative Moment)")
- Top flange fully braced for noncomposite loads:
- Noncomposite top flange cross frame spacing:  ft
- Top flange fully braced for final state:
- Final state top flange cross frame spacing:  ft (Annotated with a green bracket and text: "Top Flange Cross-Frame spacing (Positive Moment)")
- Construction lateral moment:  kip - ft

\*NOTE: Distances are measured from the left end of the current span

# Span Information – Span 3

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFD Simon

File Analyze Help

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
  - Span Information
    - Span 1
    - Span 2
    - Span 3**
  - Cross Section
    - Span 1
    - Span 2
    - Span 3 (symmetrical)
  - Costs
    - Material
    - Fabrication
    - Web Depth Optimization
    - Result Controls
  - Results

Symmetrical span Yes  ← Span 3 Symmetrical to Span 1

Span length  ft

Hinge location\*  ft

Noncomposite uniform dead load  lb / ft

Noncomposite partial dead load, A1  lb / ft

Distance\* to end of A1 load  ft

Noncomposite partial dead load, A2  lb / ft

Distance\* to beginning of A2 load  ft

Bottom flange cross frame spacing  ft

Top flange fully braced for noncomposite loads

Noncomposite top flange cross frame spacing  ft

Top flange fully braced for final state

Final state top flange cross frame spacing  ft

Construction lateral moment  kip - ft

\*NOTE: Distances are measured from the left end of the current span

# Cross Section Data – Span 1 – Web

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

LRFD Simon

Model

- General Properties
- Distribution Factors
- Material Properties
- Loads
- User Defined Design Vehicle Properties
- Transverse Stiffener Properties
- Shear Stud Properties
- Span Information
  - Span 1
  - Span 2
  - Span 3
- Cross Section
  - Span 1**
  - Span 2
  - Span 3 (symmetrical)
- Costs
  - Material
  - Fabrication
  - Web Depth Optimization
  - Result Controls
  - Results

Web | Top Flange | Bottom Flange | Slab | Field Splice | Deck Pours

	End Location, ft	Vertical web depth, left, in	Vertical web depth, right, in	Web Fy, ksi	Web thickness, in	Transversely stiffened	Top longitudinal stiffener width, in	Top longitudinal stiffener thickness, in	Bottom longitudinal stiffener width, in	Bottom longitudinal stiffener thickness, in	Reduce web thickness	Minimum transverse stiffener spacing, in
	29	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48
	58	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48
	87	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48
	116	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48
	120	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48
	145	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48
	165	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48
						<input type="checkbox"/>					<input type="checkbox"/>	
						<input type="checkbox"/>					<input type="checkbox"/>	
						<input type="checkbox"/>					<input type="checkbox"/>	







# Cross Section Data – Span 1 – Deck Slab

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
  - Span Information
    - Span 1
    - Span 2
    - Span 3
  - Cross Section
    - Span 1**
    - Span 2
    - Span 3 (symmetrical)
  - Costs
    - Material
    - Fabrication
    - Web Depth Optimization
    - Result Controls
  - Results

Web Top Flange Bottom Flange **Slab** Field Splice Deck Pours

	End Location, ft	Effective Composite Slab Width, in	Effective Composite Slab Thickness, in	Reinforcement Area, A's, in <sup>2</sup>
	120	111	8.0	0.0
	165	111	8.0	10.23

# Cross Section Data – Span 1 – Field Splice

The screenshot displays a software interface for structural analysis. The title bar reads "EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon". The menu bar includes "File", "Analyze", and "Help". The left sidebar shows a tree view with "Span 1" selected under "Cross Section". The main window has tabs for "Web", "Top Flange", "Bottom Flange", "Slab", "Field Splice", and "Deck Pours". The "Field Splice" tab is active, showing a table with the following data:

Field Splice Location, ft
120

# Cross Section Data – Span 1 – Deck Pours

The screenshot displays a software application window titled "EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon". The interface includes a menu bar with "File", "Analyze", and "Help", and a toolbar with various icons. On the left, a tree view shows the project structure, with "Span 1" under "Cross Section" highlighted with a red box. The main area shows a table with tabs for "Web", "Top Flange", "Bottom Flange", "Slab", "Field Splice", and "Deck Pours", with the "Deck Pours" tab selected and highlighted with a red box. The table contains the following data:

	Pour Number	Pour Start Location, ft	Pour End Location, ft
	1	0	120
	2	120	165

# Cross Section Data – Span 2 – Web

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

LRFD Simon

Model

- General Properties
- Distribution Factors
- Material Properties
- Loads
- User Defined Design Vehicle Properties
- Transverse Stiffener Properties
- Shear Stud Properties
- Span Information
  - Span 1
  - Span 2
  - Span 3
- Cross Section
  - Span 1
  - Span 2**
  - Span 3 (symmetrical)
- Costs
  - Material
  - Fabrication
  - Web Depth Optimization
  - Result Controls
  - Results

Web	Top Flange	Bottom Flange	Slab	Field Splice	Deck Pours								
	End Location, ft	Vertical web depth, left, in	Vertical web depth, right, in	Web Fy, ksi	Web thickness, in	Transversely stiffened	Top longitudinal stiffener width, in	Top longitudinal stiffener thickness, in	Bottom longitudinal stiffener width, in	Bottom longitudinal stiffener thickness, in	Reduce web thickness	Minimum transverse stiffener spacing, in	
	20	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
	52	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
	55	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
	84	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
	116	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
	145	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
	148	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
	180	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
	200	80	80	50	0.6875	<input checked="" type="checkbox"/>					<input type="checkbox"/>	48	
						<input type="checkbox"/>					<input type="checkbox"/>		





# Cross Section Data – Span 2 – Deck Slab

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

Web Top Flange Bottom Flange **Slab** Field Splice Deck Pours

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
- Span Information
  - Span 1
  - Span 2
  - Span 3
- Cross Section
  - Span 1
  - Span 2**
  - Span 3 (symmetrical)
- Costs
  - Material
  - Fabrication
  - Web Depth Optimization
  - Result Controls
- Results

	End Location, ft	Effective Composite Slab Width, in	Effective Composite Slab Thickness, in	Reinforcement Area, A's, in <sup>2</sup>
	55	111	8.0	10.23
▶	145	111	8.0	0.0
	200	111	8.0	10.23

# Cross Section Data – Span 2 – Field Splice

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

Field Splice

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
  - Span Information
    - Span 1
    - Span 2
    - Span 3
  - Cross Section
    - Span 1
    - Span 2**
    - Span 3 (symmetrical)
  - Costs
    - Material
    - Fabrication
    - Web Depth Optimization
    - Result Controls
  - Results

Web	Top Flange	Bottom Flange	Slab	Field Splice	Deck Pours
				Field Splice Location, ft	
				55	
				145	



# Cross Section Data – Span 2 – Deck Pours

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

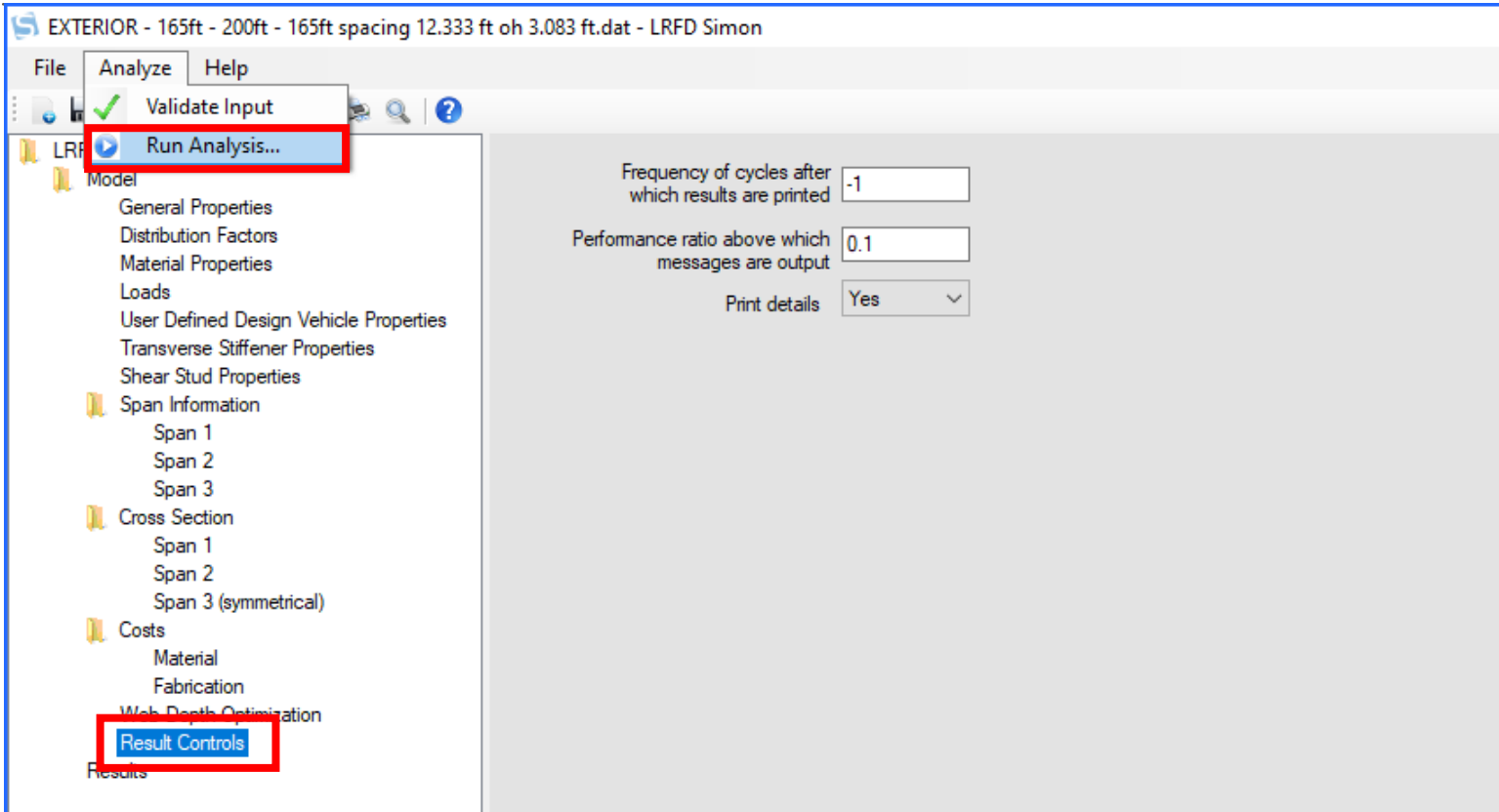
LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
  - Span Information
    - Span 1
    - Span 2
    - Span 3
  - Cross Section
    - Span 1
    - Span 2**
    - Span 3 (symmetrical)
  - Costs
    - Material
    - Fabrication
    - Web Depth Optimization
    - Result Controls
  - Results

Web Top Flange Bottom Flange Slab Field Splice **Deck Pours**

	Pour Number	Pour Start Location, ft	Pour End Location, ft
	2	0	55
	1	55	145
	2	145	200

# LRFD Simon – Run the Analysis



# LRFD Simon – Results File

## Results Files in SIMON, .XML, and .OUT (notepad)

**LRFD Simon**  
Version 10.3.0.0 2021-06-10 16:25

Vehicle library: NSBA\_Vehicle\_Data.txt  
Program library: NSBA\_simon\_library\_data.txt  
Agency library: NSBA\_library\_data.txt

Job Name: NSBA/SSSBA Summer Webinar Series  
Project Name: LRFD Simon Tutorial  
Description: Steel Plate I-Girder Bridge

EXTERIOR - Spacing 12.333 ft - 3' - 1" Overhangs  
AASHTO LRFD BDS, COMPOSITE, HL93 LOADING  
3-Span-Continuous (165'-200'-165'), Four Girders

National Steel Bridge Alliance  
American Institute of Steel Construction  
130 East Randolph Street  
Suite 2000  
Chicago, IL 60601

For assistance contact: The National Steel Bridge Alliance: nsbasimon@steelbridges.org

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Note: License expires on 2028-Jan-01 (in 2397 days).  
National Steel Bridge Alliance - Perpetual  
130 East Randolph, Suite 2000  
Chicago IL 60601 United States

No Input Validation Errors or Warnings Detected

**LRFD Simon**  
Version 10.3.0.0 2021-06-10 16:25

Vehicle library: NSBA\_Vehicle\_Data.txt  
Program library: NSBA\_simon\_library\_data.txt  
Agency library: NSBA\_library\_data.txt

Job Name: NSBA/SSSBA Summer Webinar Series  
Project Name: LRFD Simon Tutorial  
Description: Steel Plate I-Girder Bridge

EXTERIOR - Spacing 12.333 ft - 3' - 1" Overhangs  
AASHTO LRFD BDS, COMPOSITE, HL93 LOADING  
3-Span-Continuous (165'-200'-165'), Four Girders

National Steel Bridge Alliance  
American Institute of Steel Construction  
130 East Randolph Street  
Suite 2000  
Chicago, IL 60601

For assistance contact: The National Steel Bridge Alliance: nsbasimon@steelbridges.org

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National Steel Bridge Alliance - Perpetual  
130 East Randolph, Suite 2000  
Chicago IL 60601 United States

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- [Secondary Level Input Parameters](#)
- [Primary Level Input Information for Cycle: 1](#)

**LRFD Simon**  
Version 10.3.0.0 2021-JUN-10 16:25:51

Vehicle library: NSBA\_Vehicle\_Data.txt  
Program library: NSBA\_simon\_library\_data.txt  
Agency library: NSBA\_library\_data.txt

Job Name: NSBA/SSSBA Summer Webinar Series  
Project Name: LRFD Simon Tutorial  
Description: Steel Plate I-Girder Bridge

EXTERIOR - Spacing 12.333 ft - 3' - 1" Overhangs  
AASHTO LRFD BDS, COMPOSITE, HL93 LOADING  
3-Span-Continuous (165'-200'-165'), Four Girders

National Steel Bridge Alliance  
American Institute of Steel Construction  
130 East Randolph Street  
Suite 2000  
Chicago, IL 60601

For assistance contact: The National Steel Bridge Alliance: nsbasimon@steelbridges.org

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Note: License expires on 2028-Jan-01 (in 2397 days).  
National Steel Bridge Alliance - Perpetual  
130 East Randolph, Suite 2000  
Chicago IL 60601 United States

**SECONDARY LEVEL INPUT PARAMETERS**

Maximum Performance Ratio for Redesign:	0.900
Minimum Performance Ratio for Constraint Messages:	0.100
Frequency of Cycles after which Results are Printed:	Last Only
Live Load Deflection Factor:	800
Distance from Interior Reaction to Stud:	0.000 Feet
Maximum Plate Thickness:	3.000 Inch
Number of Design Traffic Lanes:	3
Number of Girders:	4
Maximum Transverse Stiffener Spacing:	384.000 Inch
Box Girder Run?: No	
Minimum Flange Thickness:	0.750 Inch
Stud Shear Connectors:	Design
Maximum Acceptable Performance Ratio:	1.000
Modular Ratio, n:	7.300
Slab Compressive Strength:	5000.000 Psi
Reinforcement Yield Strength:	60.000 Ksi

Ln 1, Col 1 100% Windows (CRLF) UTF-8

# LRFD Simon – Results Review

## Moments Results

Span: 1

Point	Girder	Other DCI	Comp DL	Utility	FWS
0.0	0.0	0.0	0.0	0.0	0.0
0.1	146.0	915.0	160.3	0.0	154.2
0.2	247.8	1534.4	269.7	0.0	259.3
0.3	305.4	1858.3	328.1	0.0	315.5
0.4	315.8	1886.6	335.5	0.0	322.6
0.5	276.0	1619.3	292.0	0.0	280.8
0.6	186.1	1056.5	197.5	0.0	189.9
0.7	45.9	198.1	52.1	0.0	50.1
0.8	-145.6	-955.9	-144.3	0.0	-138.7
0.9	-389.1	-2405.4	-391.6	0.0	-376.6
1.0	-697.5	-4150.6	-690.0	0.0	-663.4

Span: 1

Point	HL93		USER DEFINED DESIGN VEHICLE		ENVELOPE		FATIGUE	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	1490.5	-255.2	0.0	0.0	1490.5	-255.2	622.0	-97.1
0.2	2551.7	-510.4	0.0	0.0	2551.7	-510.4	1038.3	-194.3
0.3	3206.7	-765.7	0.0	0.0	3206.7	-765.7	1299.9	-291.4
0.4	3507.5	-1020.9	0.0	0.0	3507.5	-1020.9	1385.1	-388.5
0.5	3466.3	-1276.1	0.0	0.0	3466.3	-1276.1	1345.3	-485.7
0.6	3119.8	-1531.3	0.0	0.0	3119.8	-1531.3	1221.0	-582.8
0.7	2465.4	-1786.6	0.0	0.0	2465.4	-1786.6	958.2	-679.9
0.8	1554.3	-2459.4	0.0	0.0	1554.3	-2459.4	588.4	-777.1
0.9	692.3	-2988.1	0.0	0.0	692.3	-2988.1	217.1	-874.2
1.0	600.5	-4087.4	0.0	0.0	600.5	-4087.4	241.2	-971.4

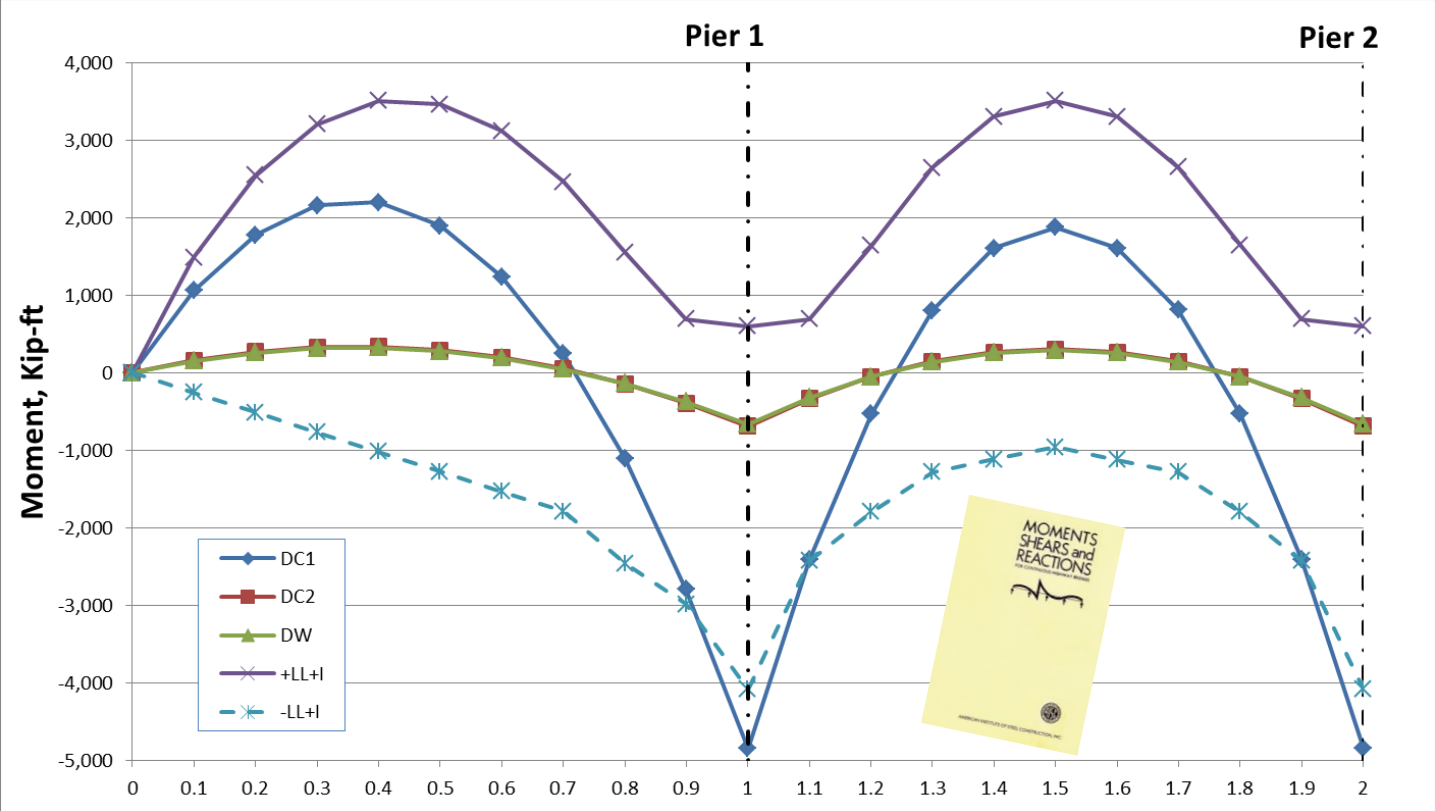
Span: 2

Point	Girder	Other DCI	Comp DL	Utility	FWS
0.0	-697.5	-4150.6	-690.0	0.0	-663.4
0.1	-339.5	-2072.3	-331.6	0.0	-318.9
0.2	-76.1	-455.9	-52.9	0.0	-50.9
0.3	108.4	698.7	146.1	0.0	140.5
0.4	218.9	1391.5	265.6	0.0	255.3
0.5	256.0	1622.4	305.4	0.0	293.6
0.6	219.6	1391.5	265.6	0.0	255.4
0.7	109.8	698.8	146.1	0.0	140.5
0.8	-74.8	-455.7	-52.9	0.0	-50.9
0.9	-338.8	-2072.1	-331.6	0.0	-318.8
1.0	-697.4	-4150.3	-689.9	0.0	-663.4

Span: 2

Point	HL93		USER DEFINED DESIGN VEHICLE		ENVELOPE		FATIGUE	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
0.0	600.5	-4087.4	0.0	0.0	600.5	-4087.4	241.2	-971.4
0.1	692.0	-2428.0	0.0	0.0	692.0	-2428.0	245.9	-694.8
0.2	1642.3	-1795.5	0.0	0.0	1642.3	-1795.5	683.2	-590.8
0.3	2650.9	-1279.9	0.0	0.0	2650.9	-1279.9	1071.8	-486.8
0.4	3303.6	-1120.3	0.0	0.0	3303.6	-1120.3	1305.4	-382.8
0.5	3511.4	-961.6	0.0	0.0	3511.4	-961.6	1361.2	-279.4
0.6	3304.6	-1121.5	0.0	0.0	3304.6	-1121.5	1305.7	-383.5
0.7	2653.0	-1281.5	0.0	0.0	2653.0	-1281.5	1072.8	-487.6
0.8	1645.5	-1798.2	0.0	0.0	1645.5	-1798.2	684.5	-591.7
0.9	693.2	-2430.3	0.0	0.0	693.2	-2430.3	246.3	-695.8
1.0	600.5	-4086.8	0.0	0.0	600.5	-4086.8	241.2	-970.0

# LRFD Simon – Results Review



# LRFD Simon – Results Review

## Shear Results

Span: 1

Point	Girder	Other DCI	Comp DL	Utility	FWS
0.0	12.0	75.9	13.3	0.0	12.8
0.1	8.8	54.8	9.6	0.0	9.3
0.2	5.7	33.7	6.0	0.0	5.8
0.3	2.5	12.6	2.4	0.0	2.3
0.4	-1.0	-8.5	-1.3	0.0	-1.2
0.5	-4.6	-29.6	-4.9	0.0	-4.7
0.6	-8.2	-50.8	-8.6	0.0	-8.2
0.7	-11.8	-71.9	-12.2	0.0	-11.7
0.8	-15.5	-93.0	-15.8	0.0	-15.2
0.9	-19.3	-114.1	-19.5	0.0	-18.7
1.0	-24.8	-135.2	-23.1	0.0	-22.2

Span: 1

Point	HL93		USER DEFINED DESIGN VEHICLE		ENVELOPE		FATIGUE	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
0.0	122.1	-18.2	0.0	0.0	122.1	-18.2	52.0	-6.9
0.1	102.7	-18.8	0.0	0.0	102.7	-18.8	44.4	-6.9
0.2	84.8	-25.1	0.0	0.0	84.8	-25.1	37.1	-7.8
0.3	68.3	-38.9	0.0	0.0	68.3	-38.9	30.1	-13.2
0.4	53.3	-53.4	0.0	0.0	53.3	-53.4	23.5	-20.6
0.5	39.9	-68.3	0.0	0.0	39.9	-68.3	17.4	-27.8
0.6	28.2	-83.5	0.0	0.0	28.2	-83.5	11.9	-34.7
0.7	18.3	-98.8	0.0	0.0	18.3	-98.8	7.1	-41.1
0.8	10.2	-114.0	0.0	0.0	10.2	-114.0	3.9	-47.0
0.9	5.0	-128.8	0.0	0.0	5.0	-128.8	1.7	-52.2
1.0	4.3	-143.0	0.0	0.0	4.3	-143.0	1.7	-56.7

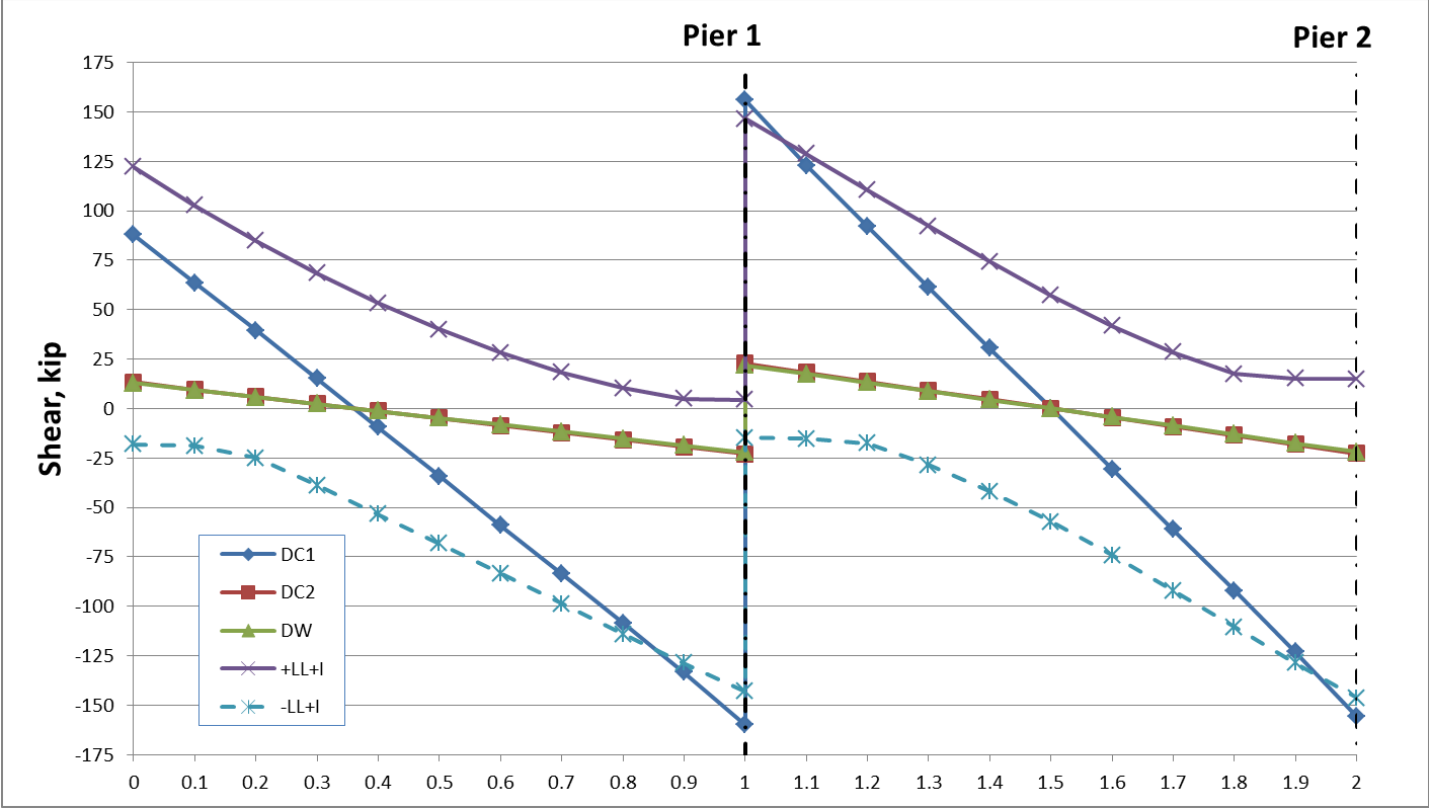
Span: 2

Point	Girder	Other DCI	Comp DL	Utility	FWS
0.0	23.9	132.0	22.8	0.0	21.9
0.1	17.3	105.6	18.2	0.0	17.5
0.2	12.8	79.2	13.7	0.0	13.1
0.3	8.4	52.8	9.1	0.0	8.8
0.4	4.2	26.4	4.6	0.0	4.4
0.5	0.0	0.0	0.0	0.0	0.0
0.6	-4.2	-26.4	-4.5	0.0	-4.4
0.7	-8.4	-52.8	-9.1	0.0	-8.7
0.8	-12.8	-79.2	-13.6	0.0	-13.1
0.9	-17.4	-105.6	-18.2	0.0	-17.5
1.0	-23.9	-131.9	-22.7	0.0	-21.9

Span: 2

Point	HL93		USER DEFINED DESIGN VEHICLE		ENVELOPE		FATIGUE	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
0.0	146.4	-14.8	0.0	0.0	146.4	-14.8	57.0	-5.9
0.1	128.8	-15.2	0.0	0.0	128.8	-15.2	51.5	-5.9
0.2	110.5	-17.5	0.0	0.0	110.5	-17.5	45.1	-5.9
0.3	92.1	-28.5	0.0	0.0	92.1	-28.5	38.1	-10.1
0.4	74.2	-41.9	0.0	0.0	74.2	-41.9	30.8	-16.4
0.5	57.2	-57.2	0.0	0.0	57.2	-57.2	23.4	-23.4
0.6	41.9	-74.1	0.0	0.0	41.9	-74.1	16.4	-30.7
0.7	28.5	-92.1	0.0	0.0	28.5	-92.1	10.1	-38.1
0.8	17.5	-110.5	0.0	0.0	17.5	-110.5	5.9	-45.1
0.9	15.2	-128.8	0.0	0.0	15.2	-128.8	5.9	-51.5
1.0	14.8	-146.4	0.0	0.0	14.8	-146.4	5.9	-57.0

# LRFD Simon – Results Review



# Simon – Web Depth Optimizer (Design Mode)

Design EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFD Simon

File Analyze Help

LRFD Simon

Model

**General Properties**

Material Properties

Loads

User Defined Design Vehicle Properties

Transverse Stiffener Properties

Shear Stud Properties

Span Information

Span 1

Span 2

Span 3

Cross Section

Span 1

Span 2

Span 3 (symmetrical)

Costs

Material

Fabrication

Web Depth Optimization

Result Controls

Results

Comments, line 1: EXTERIOR - Spacing 12.333 ft - 3' - 1" Overhangs

Comments, line 2: AASHTO LRFD BDS, COMPOSITE, HL93 LOADING

Comments, line 3: 3-Span-Continuous (165'-200'-165'), Four Girders

Beam type: I-Girder

Number of spans: 3

Number of girders: 4

Number of traffic lanes: 3

Run option: **LRFD Design**

Redesign performance ratio: 0.9

Maximum performance ratio: 1.0

Minimum flange thickness: 0.75 in

Maximum plate thickness: 3.0 in

Distance from slab bottom to cg of reinforcement: 4.02 in

Distance from slab bottom to web top: 4 in

Average daily truck traffic, single lane: 800

Fatigue service life: 75 years

Design EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat\* - LRFD Simon

File Analyze Help

LRFD Simon

Model

General Properties

Distribution Factors

Material Properties

Loads

User Defined Design Vehicle Properties

Transverse Stiffener Properties

Shear Stud Properties

Span Information

Span 1

Span 2

Span 3

Cross Section

Span 1

Span 2

Span 3 (symmetrical)

Costs

Material

Fabrication

**Web Depth Optimization**

Result Controls

Results

**Web optimization** Yes

Number of variations below start: 5

Number of variations above start: 5

Depth variation type: Fixed

Depth increment: 2 in or %

Web Depth Optimization Parameters



# Simon – Web Depth Optimizer Results

Design EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft oh 3.083 ft.dat - LRFD Simon

File Analyze Help

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
  - Span Information
    - Span 1
    - Span 2
    - Span 3
  - Cross Section
    - Span 1
    - Span 2
    - Span 3 (symmetrical)
  - Costs
    - Material
    - Fabrication
    - Web Depth Optimization
  - Results

LRFD Simon Version 10.3.0.0      2021-JUN-10 17:04:55

Vehicle library: NSBA\_Vehicle\_Data.txt  
 Program library: NSBA\_simon\_library\_data.txt  
 Agency library: NSBA\_library\_data.txt

Job Name: NSBA/SSSBA Summer Webinar Series  
 Project Name: LRFD Simon Tutorial  
 Description: Steel Plate I-Girder Bridge

EXTERIOR - Spacing 12.333 ft - 3' - 1" Overhangs  
 AASHTO LRFD BDS, COMPOSITE, HLS3 LOADING  
 3-Span-Continuous (165'-200'-165'), Four Girders

WEB DEPTH VARIATION ANALYSIS OUTPUT

More information about the web optimization algorithm can be found in the program User's Guide in the Program Methodologies / Web Depth Optimization section.

In the filenames given on the following table, BELOW designates design runs with web depths LESS than the original web depth, while ABOVE designates runs with web depths greater than the original. The numbers at the end of each of the filenames refer to the number of increments above or below the original web depth considered in the file. For example, a file ending in "BELOW2" considers a web depth two increments (either fixed or percentage) below the original input web depth.  
 The filename without ABOVE or BELOW at the end of the filename is the original run with web depths designated by the user.  
 If any expected output files are not shown here, it is likely that the run for that increment ended abnormally (usually, the program stopped due to an error)

All of files listed below (as well as any expected files that have crashed are available in the same folder as the original input file. Please open the desired input file to view the available program input and output. Please remember to change the WEB DEPTH OPTIMIZATION option to NO so that another web optimization is not attempted.

DEPTH VARIATION ANALYSIS

Filename	Depth Inch	Weight Tons	Cost \$
DESIGN EXTER... FT_BELOW5	70.00	372.98	452329
DESIGN EXTER... FT_BELOW4	72.00	370.74	449686
DESIGN EXTER... FT_BELOW3	74.00	366.97	445280
DESIGN EXTER... FT_BELOW2	76.00	366.31	444612
DESIGN EXTER... FT_BELOW1	78.00	364.83	442987
DESIGN EXTER... H_3.083 FT	80.00	362.05	439735
DESIGN EXTER... FT_ABOVE1	82.00	363.01	441011
DESIGN EXTER... FT_ABOVE2	84.00	361.35	439138
DESIGN EXTER... FT_ABOVE3	86.00	362.07	440121
DESIGN EXTER... FT_ABOVE4	88.00	361.37	439404
DESIGN EXTER... FT_ABOVE5	90.00	362.46	440836

The following input files were created containing the best design of each run

Variation Above      Variation Below

No Input Validation Errors or Warnings Detected

# LRFD Simon – Results Review

## All Performance Ratios Should Be Less Than 1.0

- Highest P.R. is 0.956
- Verify Interior Girder Design is Adequate
- Could Refine Further to Optimize Sections for Fabrication and Costs
- If Results P.R. More Than 1.0, Revise & Rerun
- Adjust Web Thickness and Stiffeners for Shear
- Adjust Flange Thickness & CF Locations for Flexure & Fatigue

EXTERIOR - 165ft - 200ft - 165ft spacing 12.333 ft on 3.083 ft.dat - LRFD Simon

File Analyze Help

LRFD Simon

- Model
  - General Properties
  - Distribution Factors
  - Material Properties
  - Loads
  - User Defined Design Vehicle Properties
  - Transverse Stiffener Properties
  - Shear Stud Properties
- Span Information
  - Span 1
  - Span 2
  - Span 3
- Cross Section
  - Span 1
  - Span 2
  - Span 3 (symmetrical)
- Costs
  - Material
  - Fabrication
  - Web Depth Optimization
- Results

The Maximum Performance Ratio for Cycle 1 is 0.956

The Design for Cycle 1 is acceptable.  
Steel Plate Weight per I-Girder = 96.160 tons  
(Excluding Bearing and Transverse Stiffeners)

This is the first acceptable design

**BILL OF MATERIALS**

The design considered is that from Cycle Number 1 (the last cycle)

**WEB TRANSVERSE STIFFENER DESIGN**

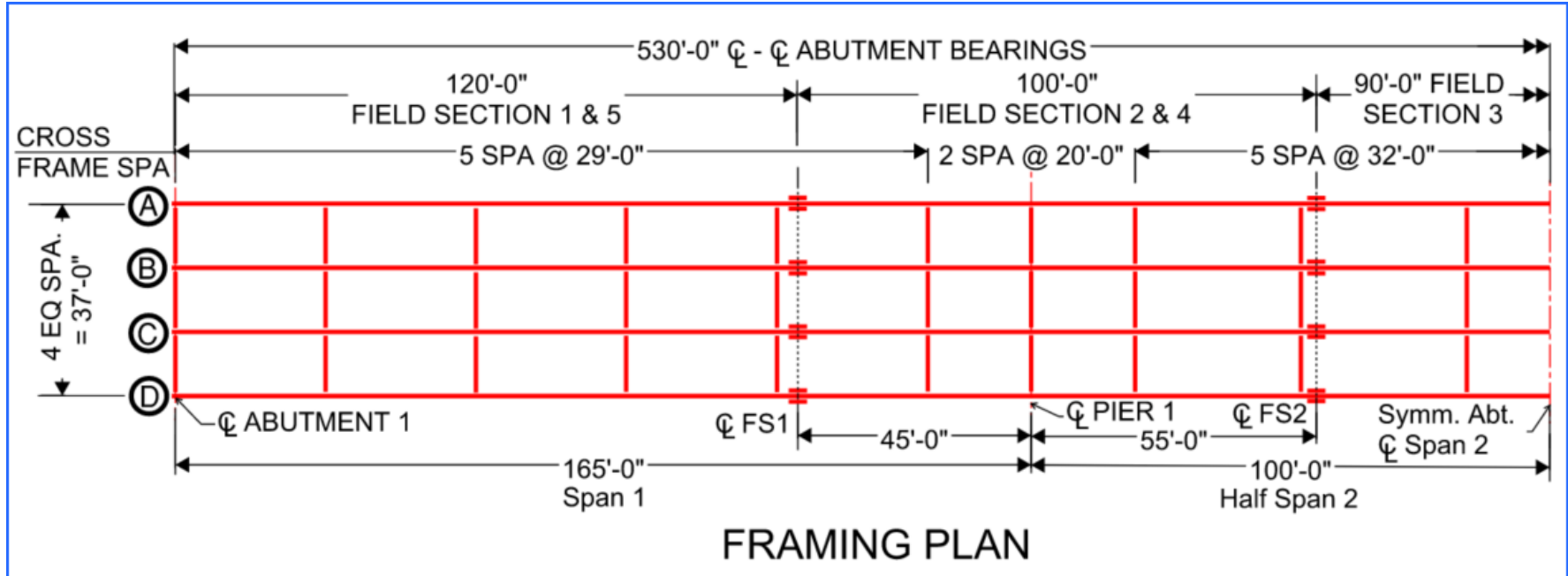
**SPAN 1**

Section	Quantity	Type	Width 0	Thickness 0	Location 0
Web Section 1	0				
Web Section 2	0				
Web Section 3	0				
Web Section 4	0				
Web Section 5	0				
Web Section 6	0				
Web Section 7	0				

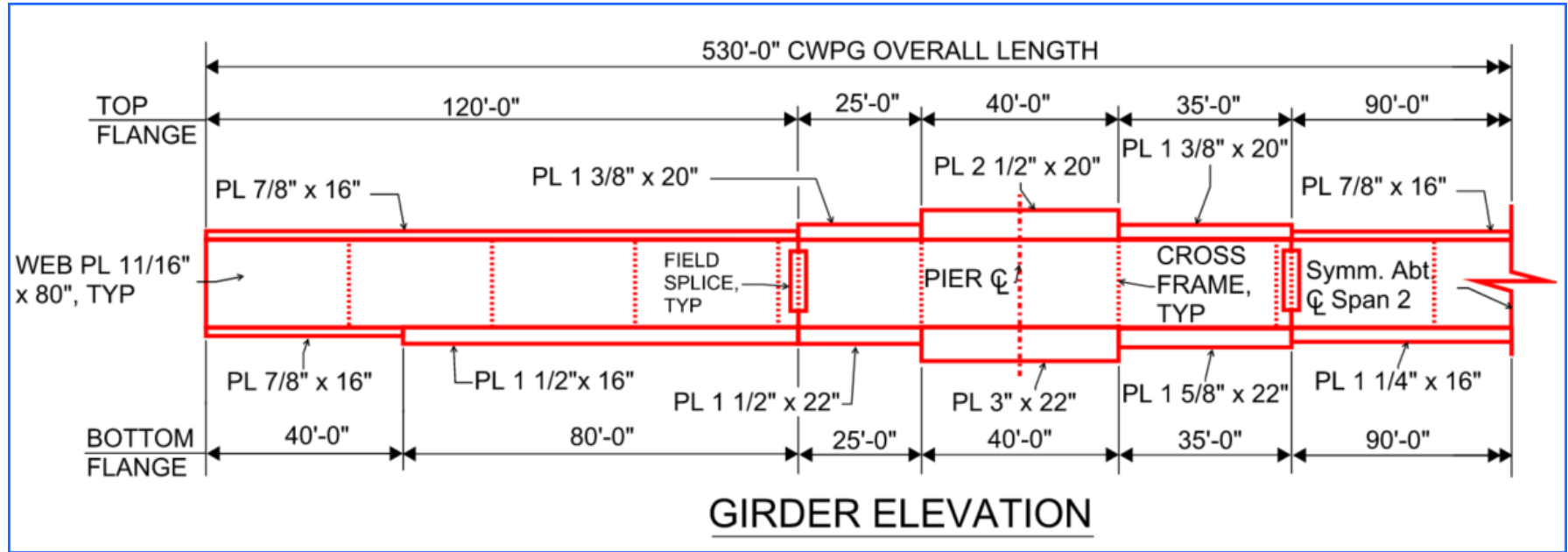
**SPAN 2**

Section	Quantity	Type	Width (in)	Thickness (in)	Location (ft)
Web Section 1	1	One Sided	5.50000	0.31250	20.00
Web Section 2	0				
Web Section 3	0				
Web Section 4	0				
Web Section 5	0				
Web Section 6	0				
Web Section 7	0				
Web Section 8	0				
Web Section 9	0				

# LRFD Simon Design Results



# LRFD Simon Design Results





Thank You! The National Steel Bridge Alliance  
Devin Altman, PE ([altman@aisc.org](mailto:altman@aisc.org)); 503.349.1106



Smarter.  
Stronger.  
Steel.