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

Live Demonstration of LRFD Simon 3-Span Bridge

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

Steel Bridge Essentials: 6 Part Summer Webinar Series – Part 2

Smarter. Stronger. Steel.

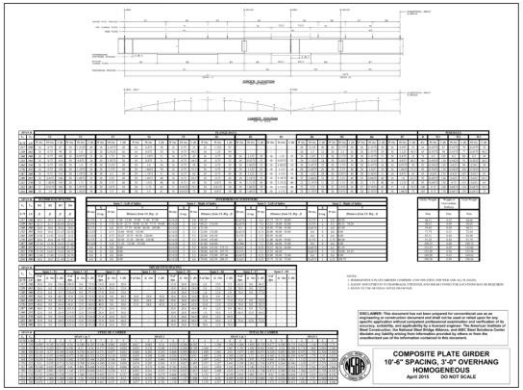
Learning Objectives

- 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

Continuous Span Standards

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

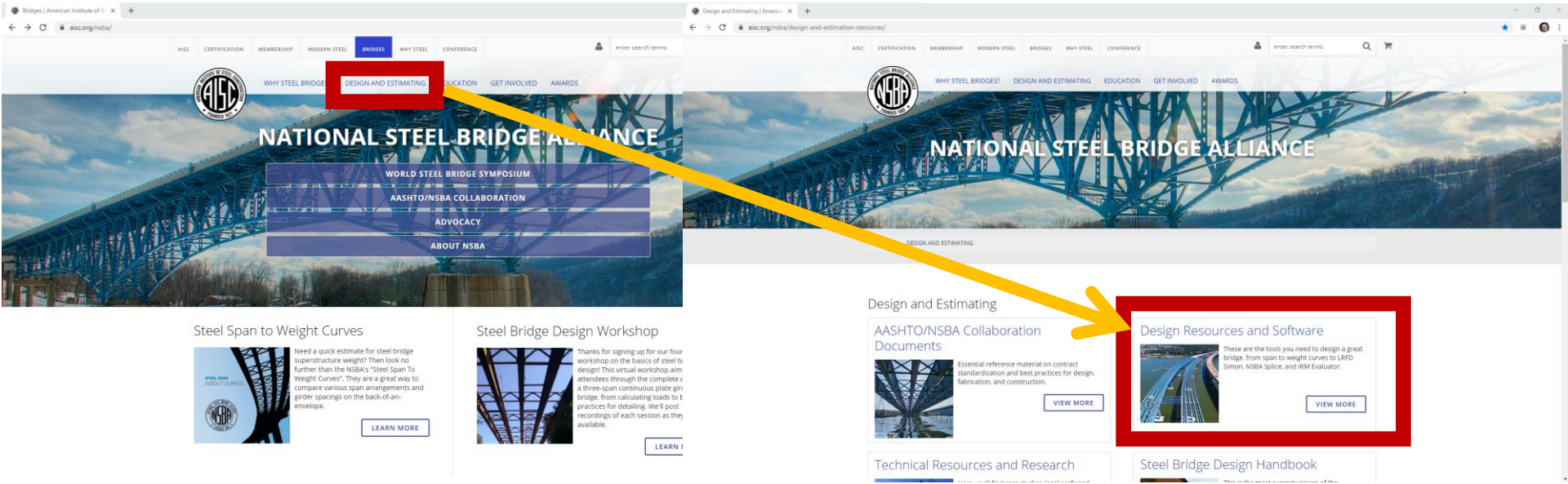


LRFD Simon

- Line girder analysis software
- Design mode, analysis mode, web depth optimization
- Per AASHTO LRFD BDS 8th Edition (update out soon)

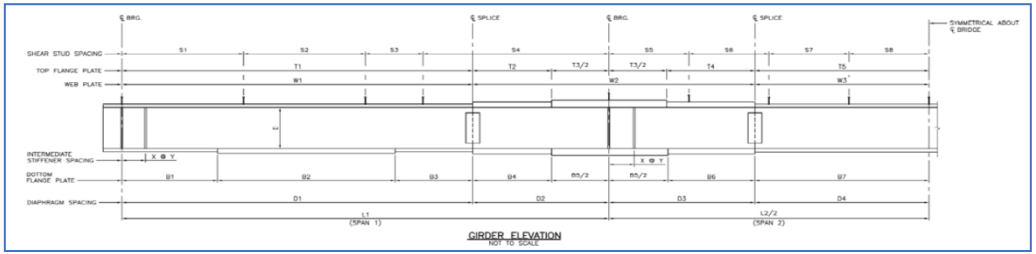
Where Can I Find These Free Design Tools

https://www.aisc.org/nsba



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



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 7th Edition LRFD
- 88 Unique Solutions

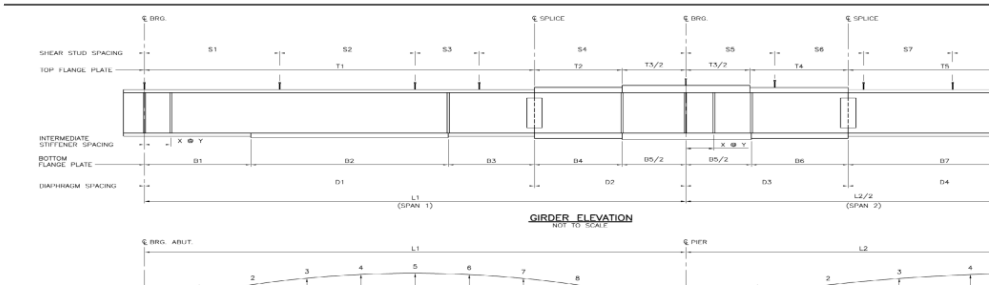


PLATE GIRDER SIZE

T2				T3				T4				T5				B1				B2				B3				B4				B5				B6				B7			
L (ft)	W (in)	Th (in)	L (ft)	W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)		W (in)	Th (in)	L (ft)	
87	18	0.875	20	20	1.3125	20		18	0.875	30		16	0.75	35		20	0.875	87		-	-	-		-	-	-		20	1.25	20		20	2.125	20		18	1.5	30		16	0.8125		
94	18	1.0625	22	20	1.625	26		18	1.25	29		16	0.75	40.5		16	1.0	94		-	-	-		-	-	-		18	1.625	22		20	2.375	26		18	1.5625	29		16	0.875		
105	18	0.75	21	20	1.375	28		18	1.625	31		16	0.75	45		16	0.75	30		16	0.8125	50		18	0.75	25		20	1.3125	21		20	2.0	28		18	2.125	31		18	0.75		
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		
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		20	1.3125	25		22	2.0	38		20	2.125	36		16	0.75		
9	18	1.375	26	20	2.375	40		18	1.1875	39		16	0.75	53.5		16	0.75	37		18	0.9375	65		18	0.9375	28		20	1.5	26		22	2.25	40		20	1.5	39		16	0.9375		
	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		
	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	1.0	40		20	1.8125	35		22	2.75	48		20	1.75	40		16	0.75		
	18	1.5	51	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	51		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	0.8125		
	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			
	X		Y		X		Y		X		Y		X		Y
Th (in)	# reg.	W (in)	Distance from CL Brg - ft	Th (in)	# reg.	W (in)	Distance from CL Brg - ft	Th (in)	# reg.	W (in)	Distance from CL Brg - ft	Th (in)	# reg.	W (in)	Distance from CL Brg - 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 34.00	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	3	5.75	17.50 35.00 49.00	0.0	0	0.0	0.00
0.313	3	4.5	9.00 102.00 120.00	0.313	2	5.5	128.00 146.00	0.438	3	6.25	18.00 36.00 54.00	0.0	0	0.0	0.00
0.313	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
0.375	4	5.0	9.25 27.75 116.50 135.00	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 45.5 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 CONNECTOR SPACING

n 1 - S3			Span 1 - S4			Span 2 - S5			Span 2 - S6			Span 2 - S7			Span 2 - S8		
ng)	L (ft)		# of Spa	@ (in)	L (ft)	# of Spa	@ (in)	L (ft)	# of Spa	@ (in)	L (ft)	# of Spa	@ (in)	L (ft)	# of Spa	@ (in)	L (ft)
	12.0		15.0	24.0	30.0	14.0	24.0	28.0	8.0	12.0	8.0	39.0	12.0	39.0	-	-	-
	13.5		16.0	24.0	32.0	15.0	24.0	30.0	9.0	12.0	9.0	34.0	9.0	25.5	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	-	-	-	-	-	-
			19.0	24.0	38.0	18.0	24.0	36.0	10.0	15.0	12.5	49.0	12.0	49.0	-	-	-
				-	-	20.0	24.0	40.0	6.0	18.0	9.0	56.0	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
			-	-		29.0	24.0	58.0	37.0	12.0	37.0	20.0	15.0	25.0	-	-	-
			-	-		30.0	24.0	60.0	54.0	15.0	67.5	-	-	-	-	-	-
	0		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
			-	-		35.0	24.0	70.0	58.0	15.0	72.5	-	-	-	-	-	-
			68.0			36.0	24.0	72.0	52.0	18.0	78.0	-	-	-	-	-	-

TOTAL DL CAMBER

	SPAN 1 & 3										SPAN 2				
5	1	2	3	4	5	6	7	8	9		1	2	3	4	5
0.471	0.768	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
55	1.048	1.912	2.465	2.645	2.456	1.964	1.304	0.657	0.188		0.279	1.010	1.903	2.626	2.896
0.863	1.571	2.019	2.16	1.995	1.577	1.012	0.455	0.073			0.383	1.085	1.868	2.489	2.722
102	2.001	2.569	2.752	2.555	2.044	1.349	0.66	0.174			0.331	1.183	2.215	3.029	3.331
7	2.439	3.119	3.324	3.062	2.422	1.575	0.757	0.191			0.414	1.537	2.432	3.332	3.671
3.189	4.072	4.352	4.036	3.255	2.162	1.11	0.338				0.36	1.463	2.854	3.982	4.406
9	4.428	4.684	4.287	3.370	2.183	1.059	0.281				0.509	1.730	3.325	4.647	5.153
3.776	4.023	3.715	2.955	1.946	0.973	0.278					0.404	1.527	2.94	4.106	4.547
903	4.207	3.871	3.067	2.013	1.00	0.289					0.358	1.527	2.619	3.69	4.097
3.916	3.603	2.849	1.859	0.912	0.248						0.415	1.424	2.711	3.773	4.175
405	4.078	3.263	2.197	1.163	0.36						0.409	1.536	3.024	4.262	4.732

NOTES:
1. HOMOGENEOUS PLATE GIRDERS COMPRIS
2. SLIGHT ADJUSTMENTS TO DIAPHRAGM, ST
3. REFER TO THE GENERAL NOTES DRAWING

COMP
7'-6" SP
Fe

LRFD Simon

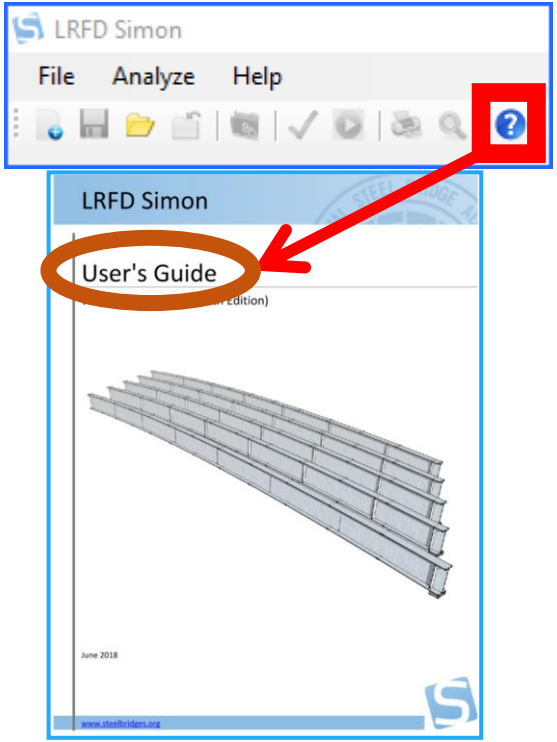
Analysis and Design Program

- Powerful Line-Girder Analysis & Design Software
- I-Girder and Box Girders Bridges
- Linear and Parabolic Haunches
- AASHTO LRFD Bridge Design Specification – 8th Edition (9th Edition LRFD Simon update coming later this summer)
- Straight Bridges with Minimal Skew

LRFD Simon

Analysis and Design Program

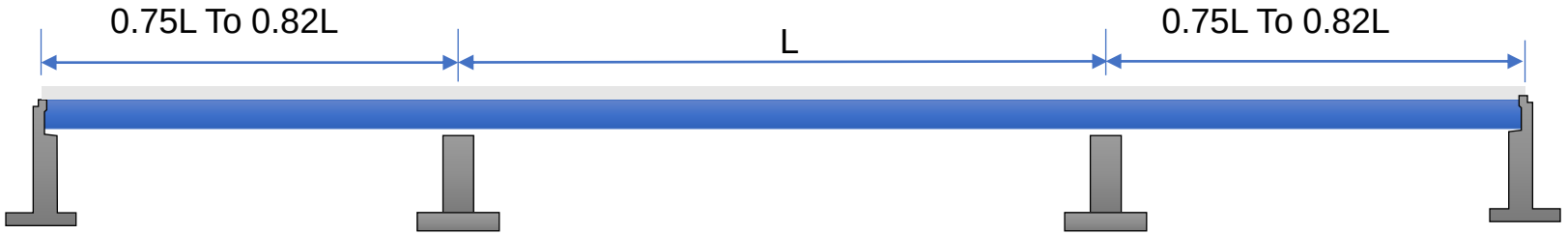
- Independently Design & Analyze both Interior and Exterior Girders
- Capable of Modeling Various Bridge Geometries and Design Loading Configurations
- Generates Service and Strength Moments, Shears, Deflections, and Bearing Reactions
- Helpful User's Guide Manual Written by Mike Grubb & Associates



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

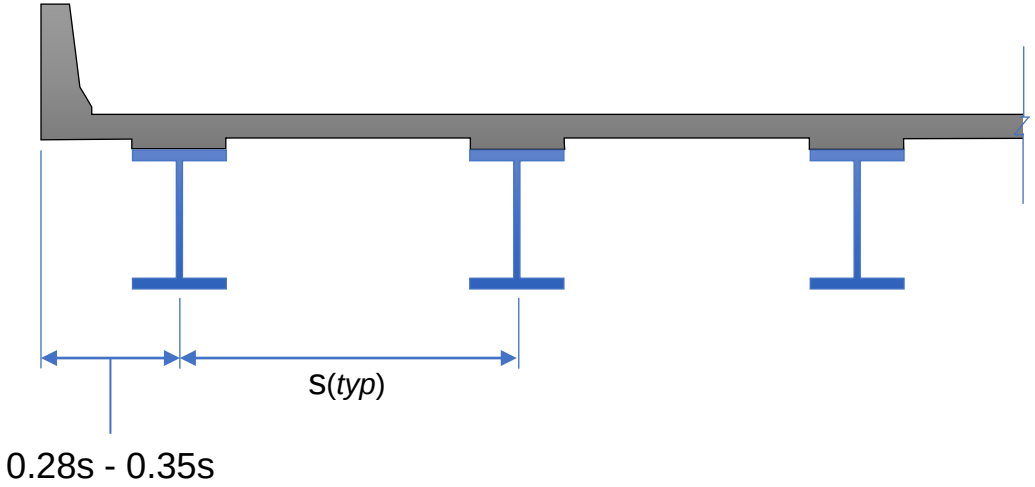


Balanced Span Arrangement

Keep in Mind Before We Get Started

Girder Spacing & Deck Overhangs

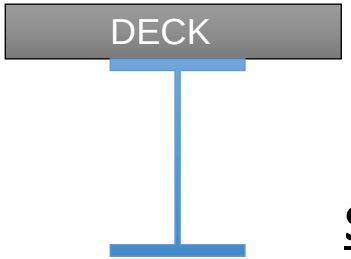
- Total factored moment tends to be larger in exterior girders (subject to lateral bridge deck overhang truck impact loads)
- Limit size of deck overhangs accordingly



Keep in Mind Before We Get Started

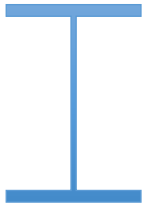
Proportioning – Web Depth

- 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



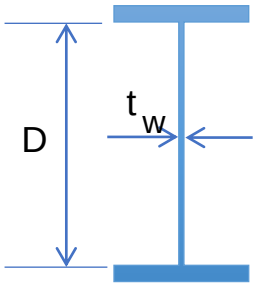
Simple Spans	0.033L
Continuous spans	0.027L

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

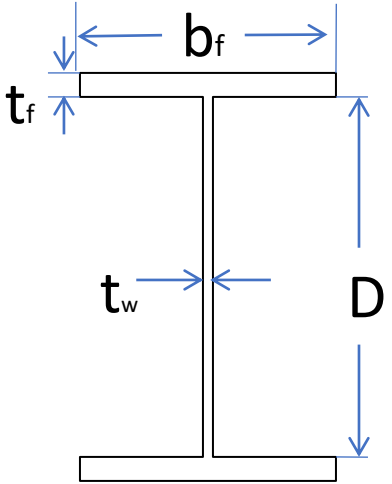
- Proportioning Requirements (AASHTO BDS Section 6.10.2.2):

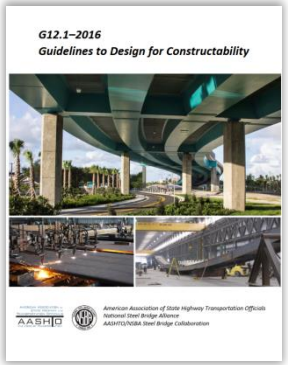
$$\frac{b_f}{2t_f} \leq 12$$

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

$$t_f \geq 1.1\, t_w$$

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





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

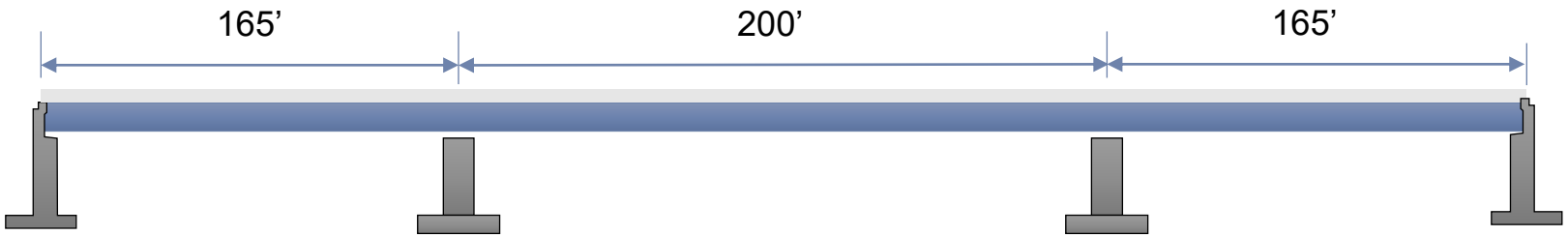
- Shipment by truck is the most common means
  - 215 ft. Possible, 80 ft. Comfortable, 80 – 120’ typical
  - Over 100 Tons Possible (20 Tons - No Permit)
  - 16 ft. Width and 10 ft. Height (depending on truck and route)
  - Girder under 9’ deep can usually be shipped vertical to anywhere

LRFD SIMON

3-Span Continuous Example

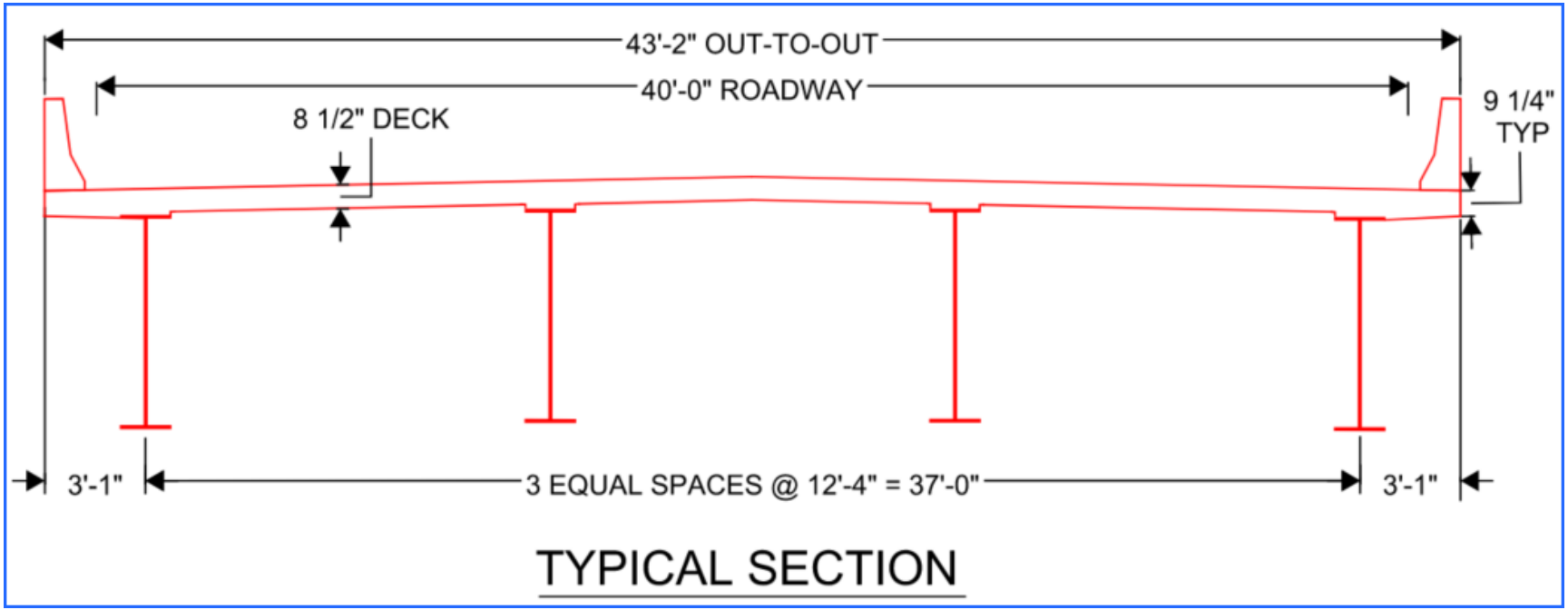
What if Your Span Layout is This?

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

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.

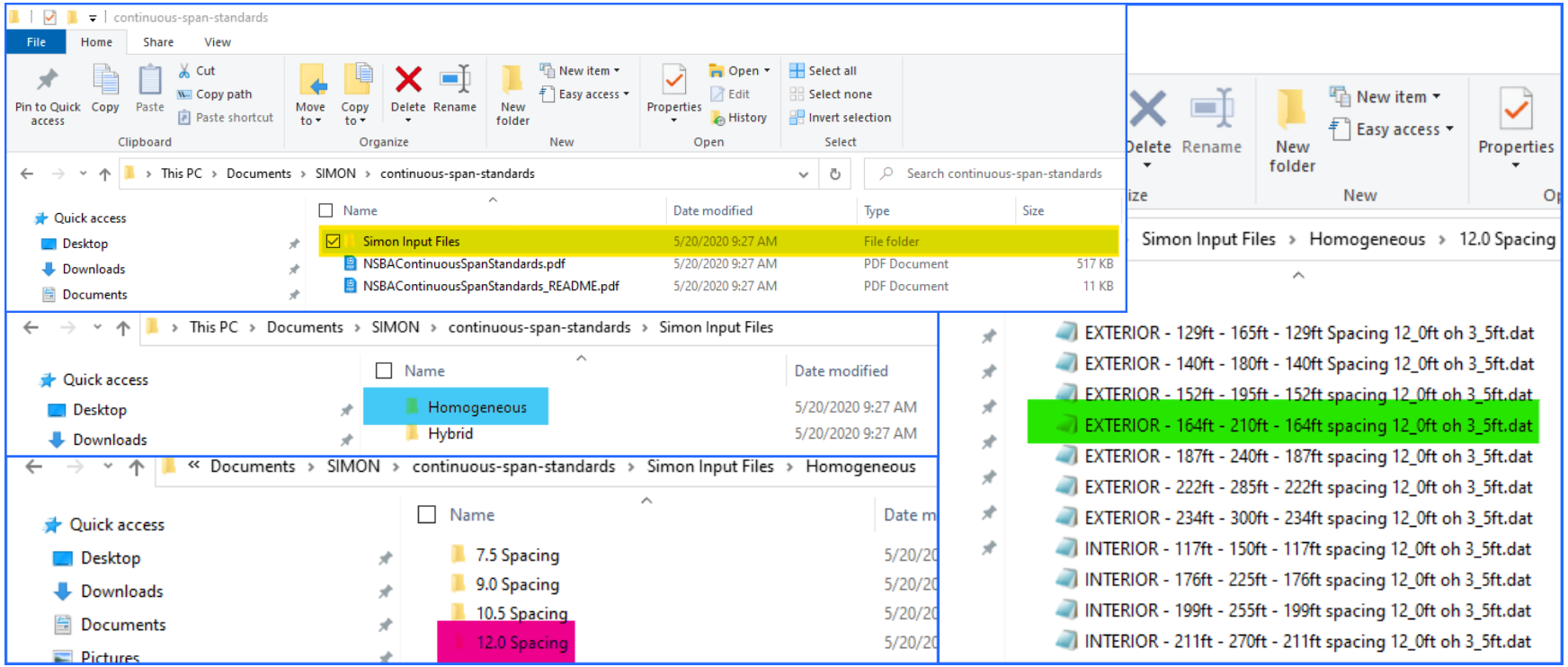
The Simon input files were provided because the NSBA understands bridge span arranges almost never match an idealized solution (ends span lengths at 78% of center span length). In providing the files, the NSBA has integrated two of its most successful resources into one powerful preliminary design tool. 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

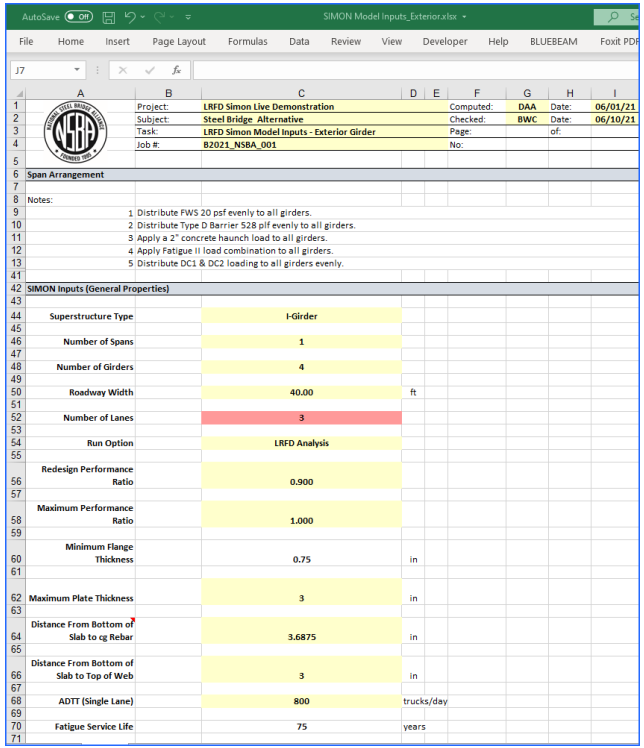
Grab LRFD Simon File Similar to Your Bridge

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



Design Girders with Project Design Criteria

I Recommend Using Excel or MathCAD Spreadsheet for Girder Design



	Project:	LRFD Simon Live Demonstration		Computed:	DAA	Date:	06/01/21
	Subject:	Steel Bridge Alternative		Checked:	BWC	Date:	06/10/21
	Task:	LRFD Simon Model Inputs - Exterior Girder		Page:		of:	
	Job #:	B2021_NSBA_001		No:			

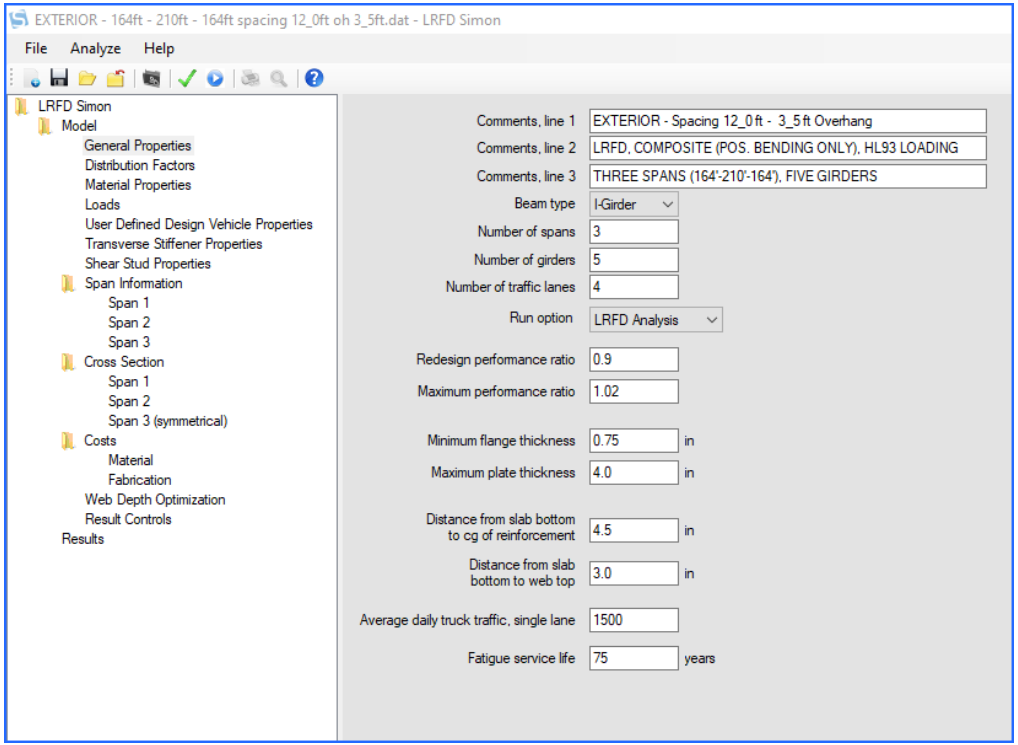
Span Arrangement

Notes:

1. Distribute FWS 20 psf evenly to all girders.
2. Distribute Type D Barrier 528 plf evenly to all girders.
3. Apply a 2" concrete haunch load to all girders.
4. Apply Fatigue II load combination to all girders.
5. Distribute DC1 & DC2 loading to all girders evenly.

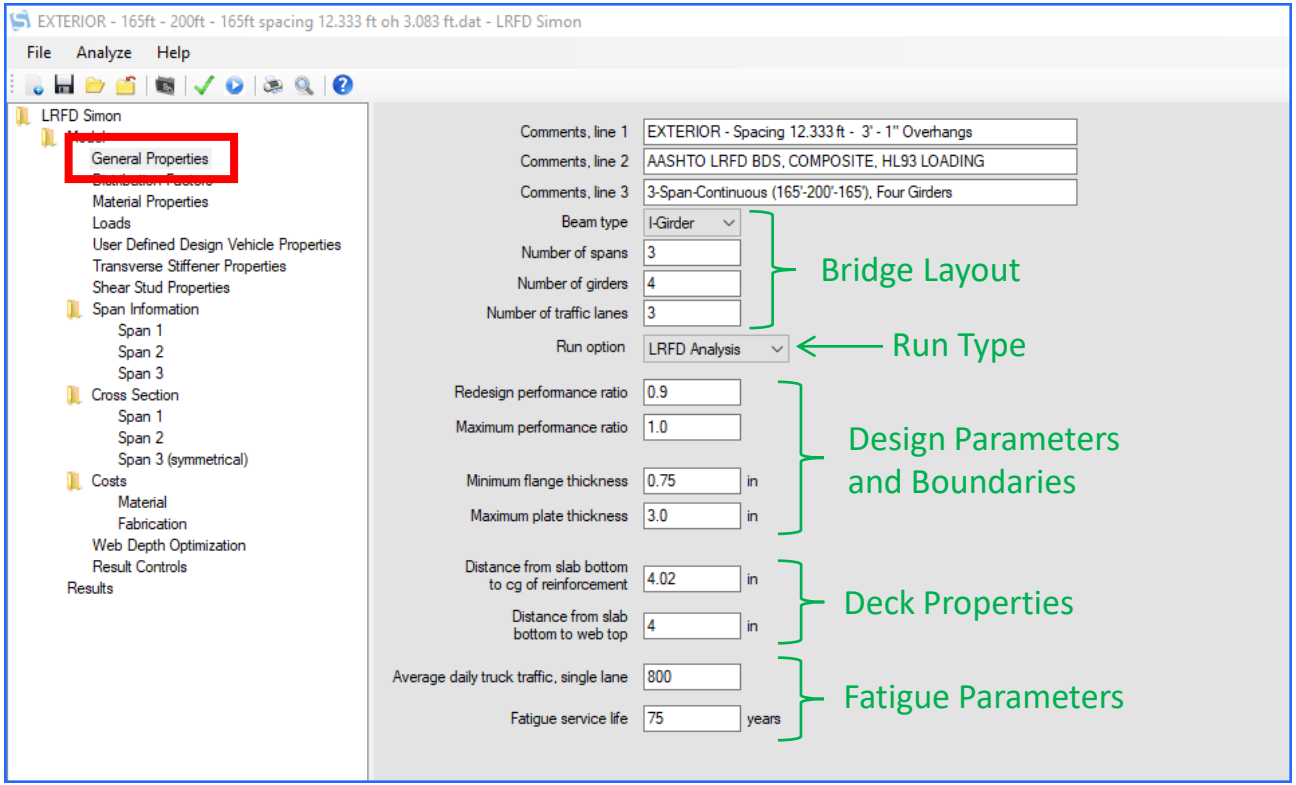
SIMON Inputs (General Properties)

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



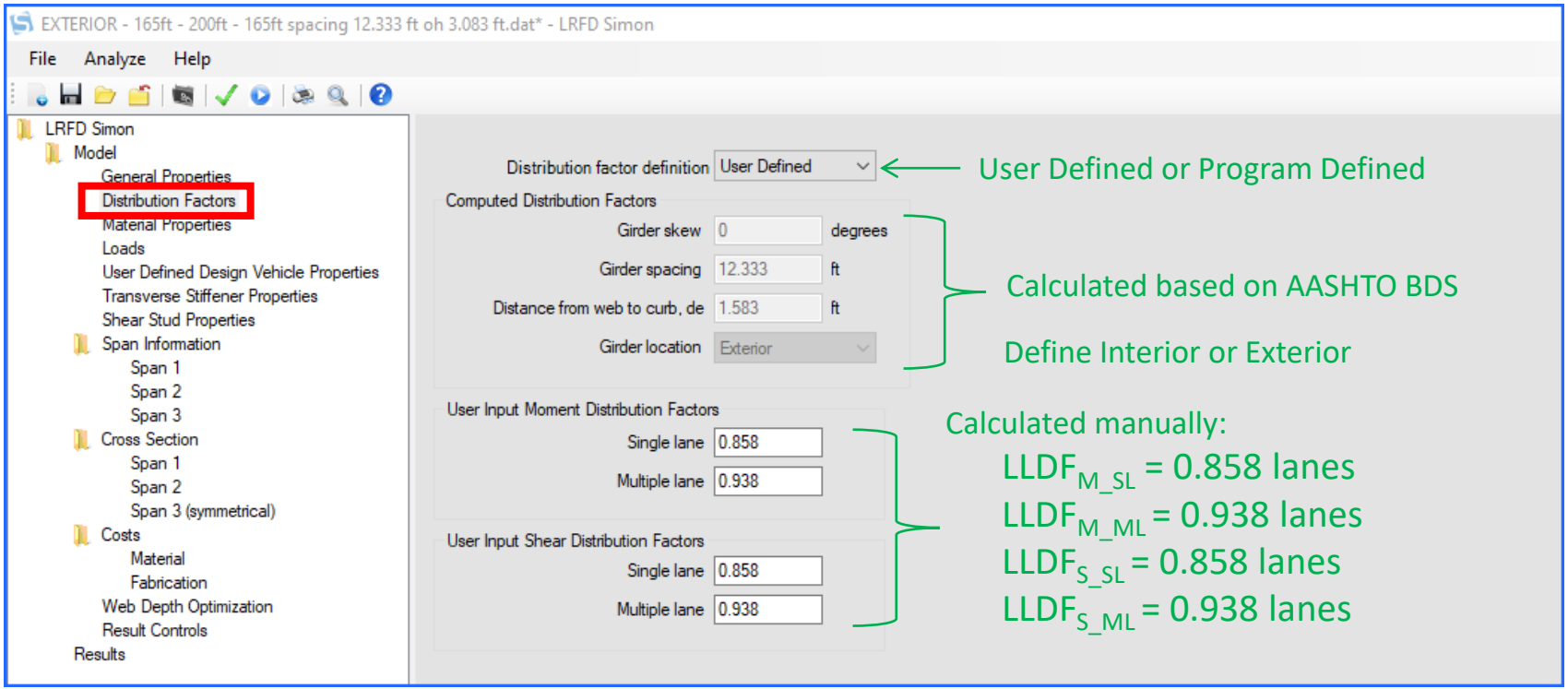
General Properties – Exterior Girder

Vet & Update LRFD Simon Inputs for Project Requirements



Distribution Factors – Exterior Girder

Vet & Update LRFD Simon Inputs for Project Requirements

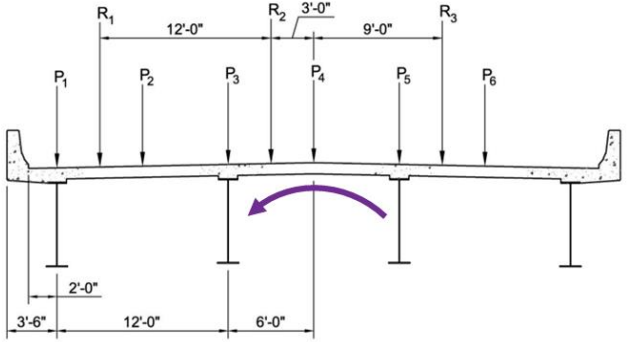


Distribution Factors – Exterior Girder

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

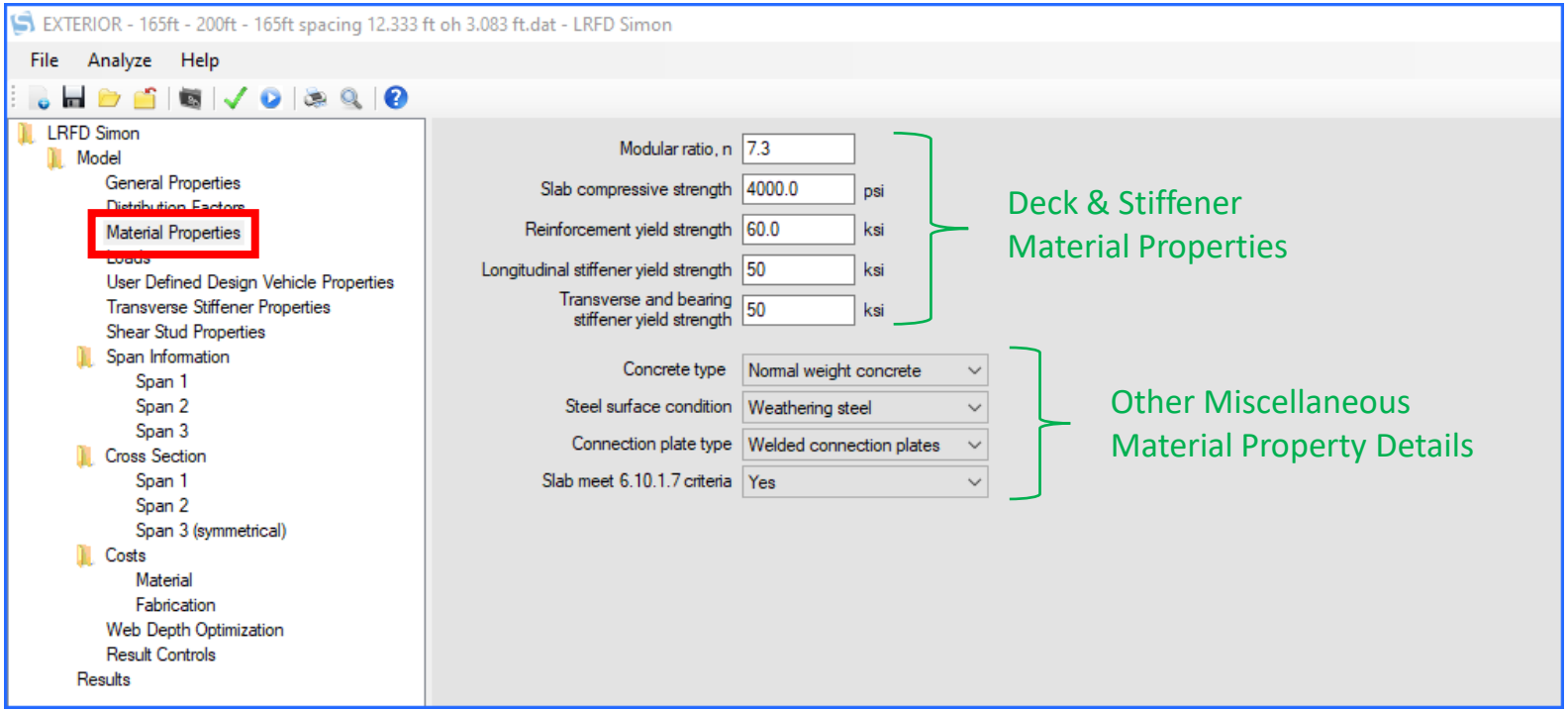
$$R = \frac{N_L}{N_b} + \frac{X_{ext}\sum^{N_L} e}{\sum^{N_b} x^2} \qquad \text{(C4.6.2.2.2d-1)}$$



- SIMON does NOT compute this LLDF currently, but will with the update coming later this summer

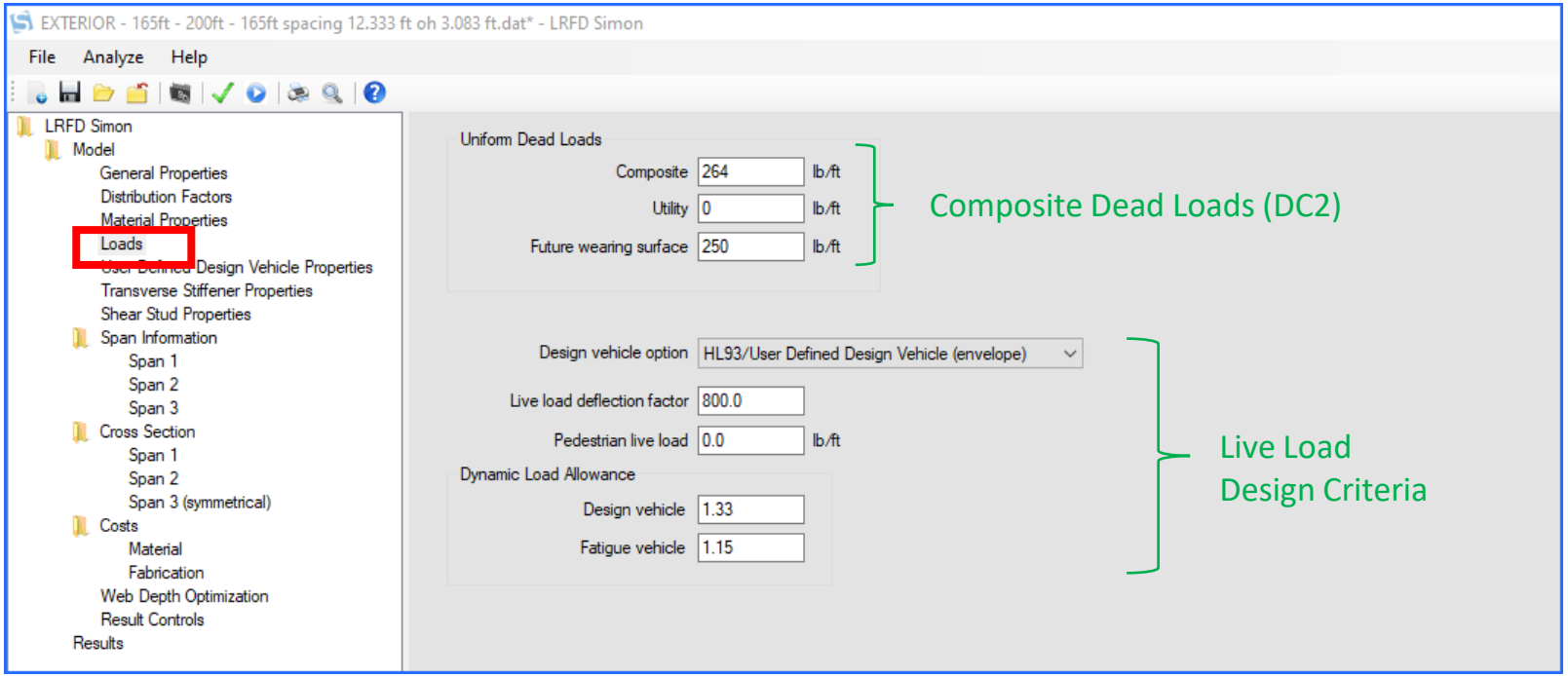
Material Properties – Exterior Girder

Vet & Update LRFD Simon Inputs for Project Requirements



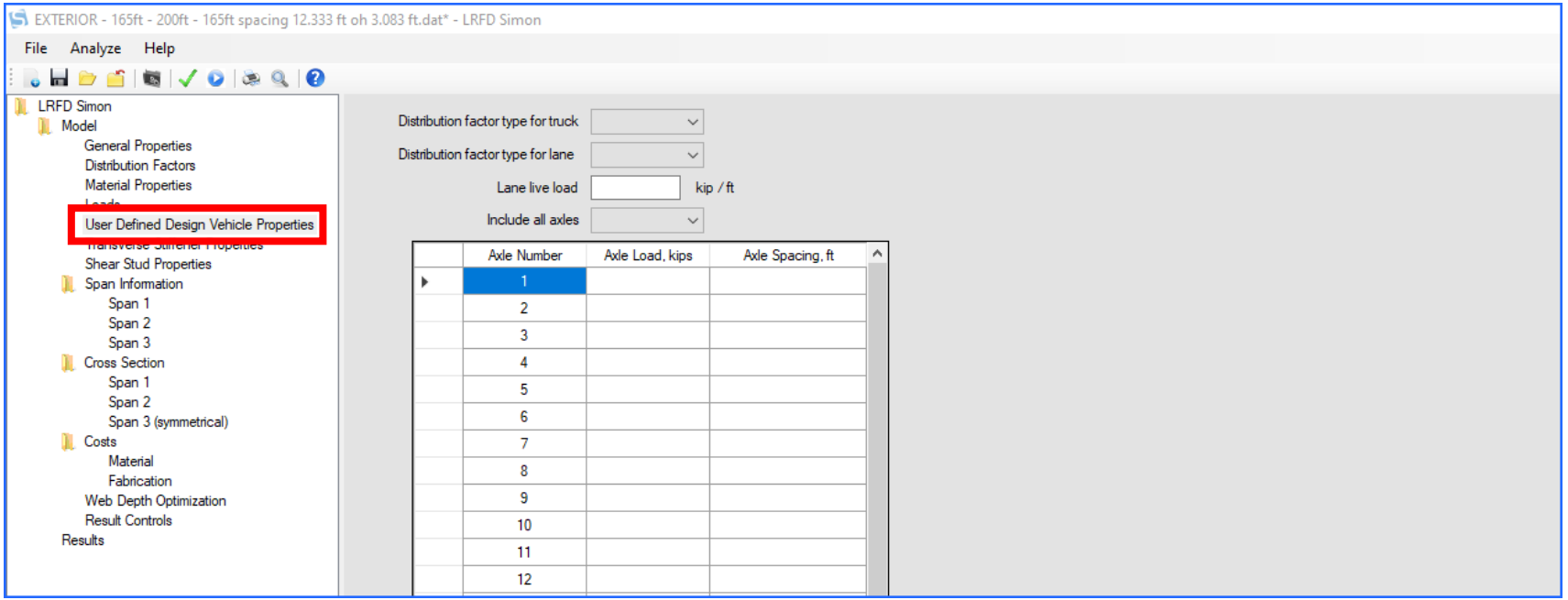
Loads –DC2 Distributed Evenly to Girders

Vet & Update LRFD Simon Inputs for Project Requirements



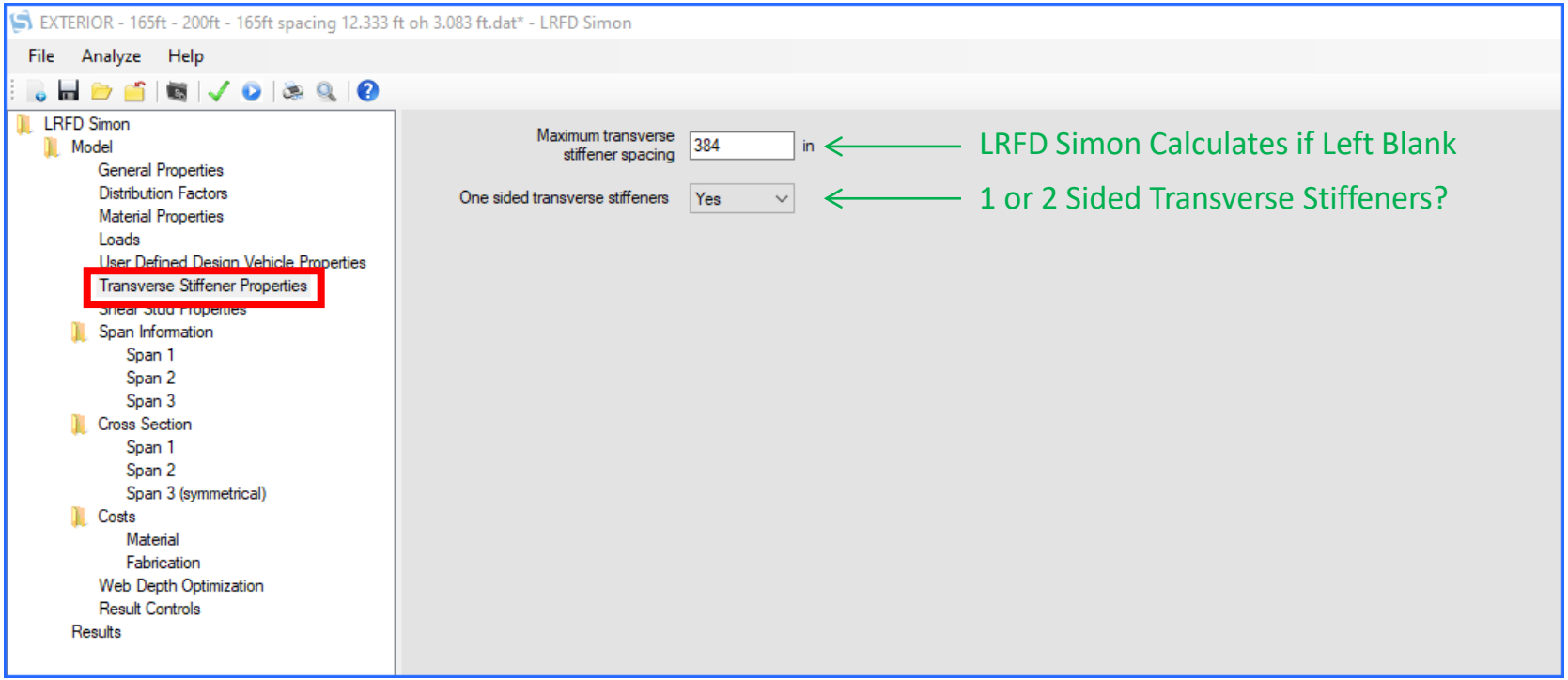
User Defined Vehicle (None for Example)

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



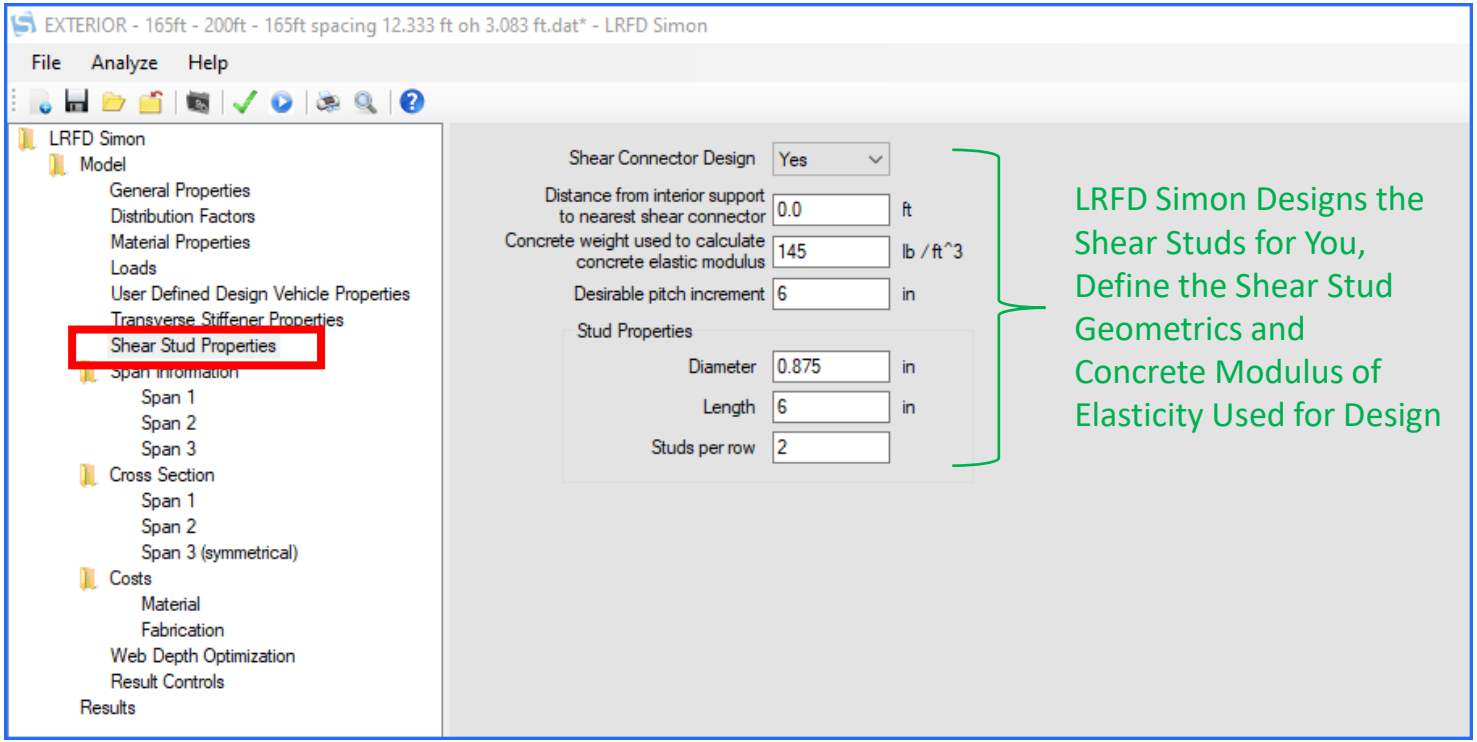
Transverse Stiffener – Exterior Girder

Vet & Update LRFD Simon Inputs for Project Requirements

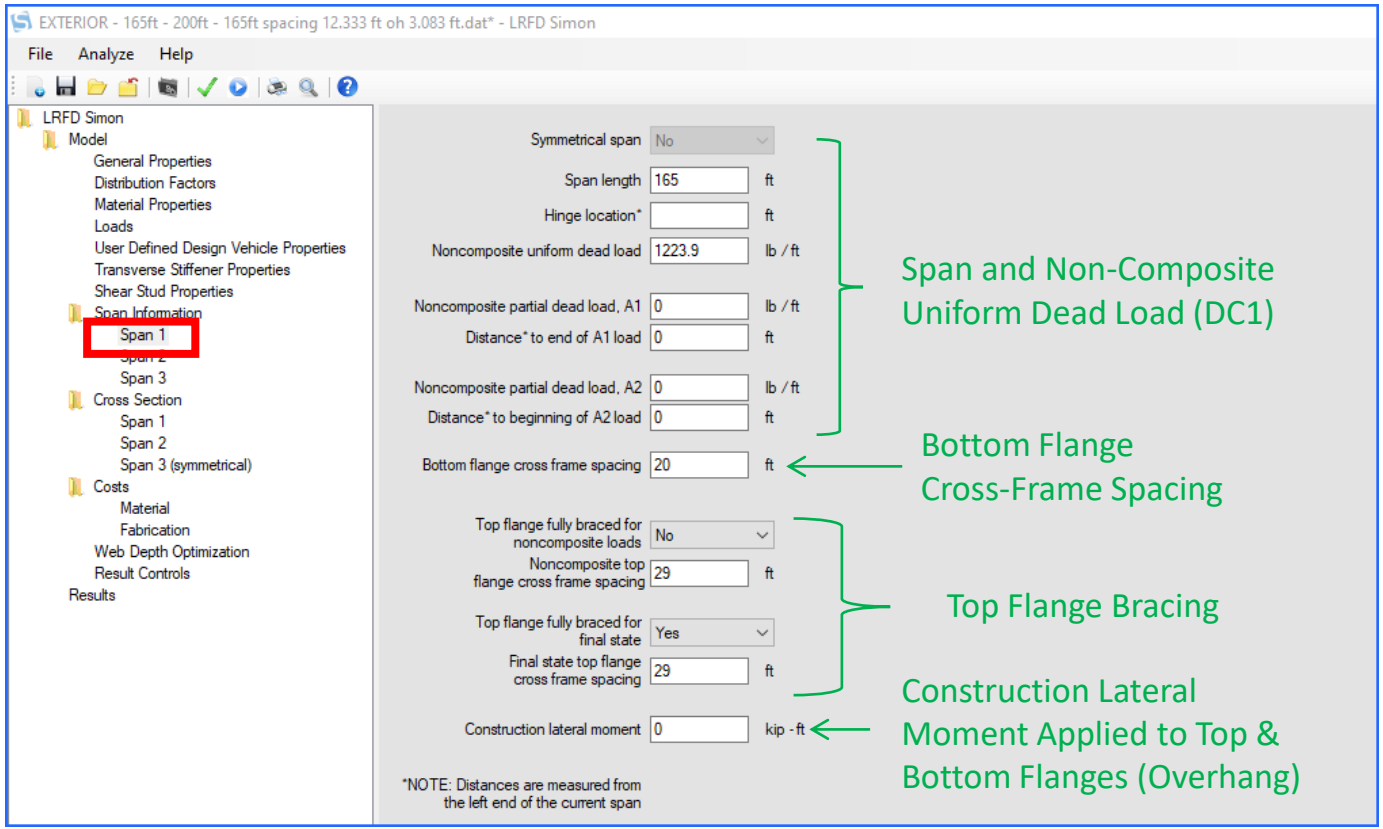


Shear Studs – Exterior Girder

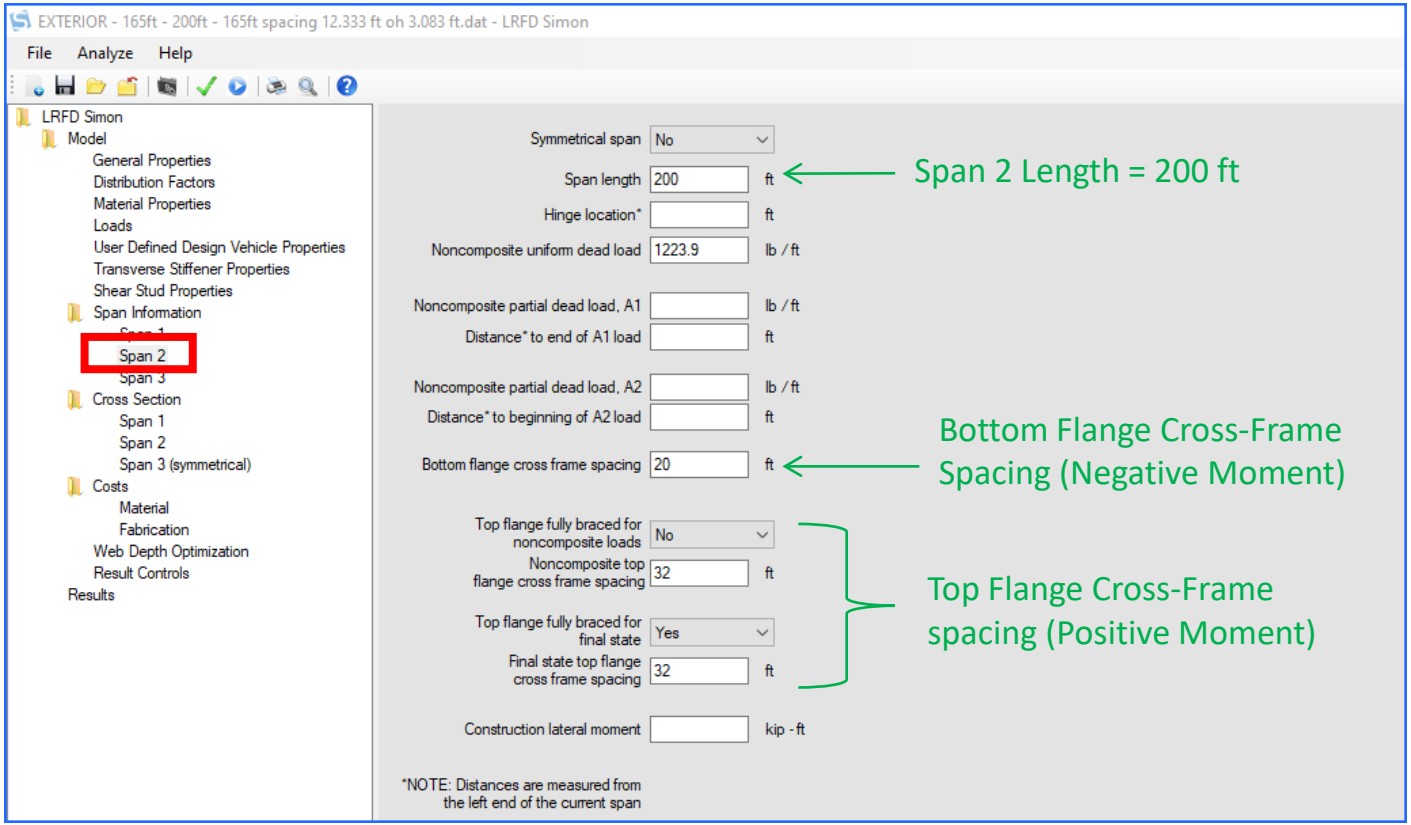
Vet & Update LRFD Simon Inputs for Project Requirements



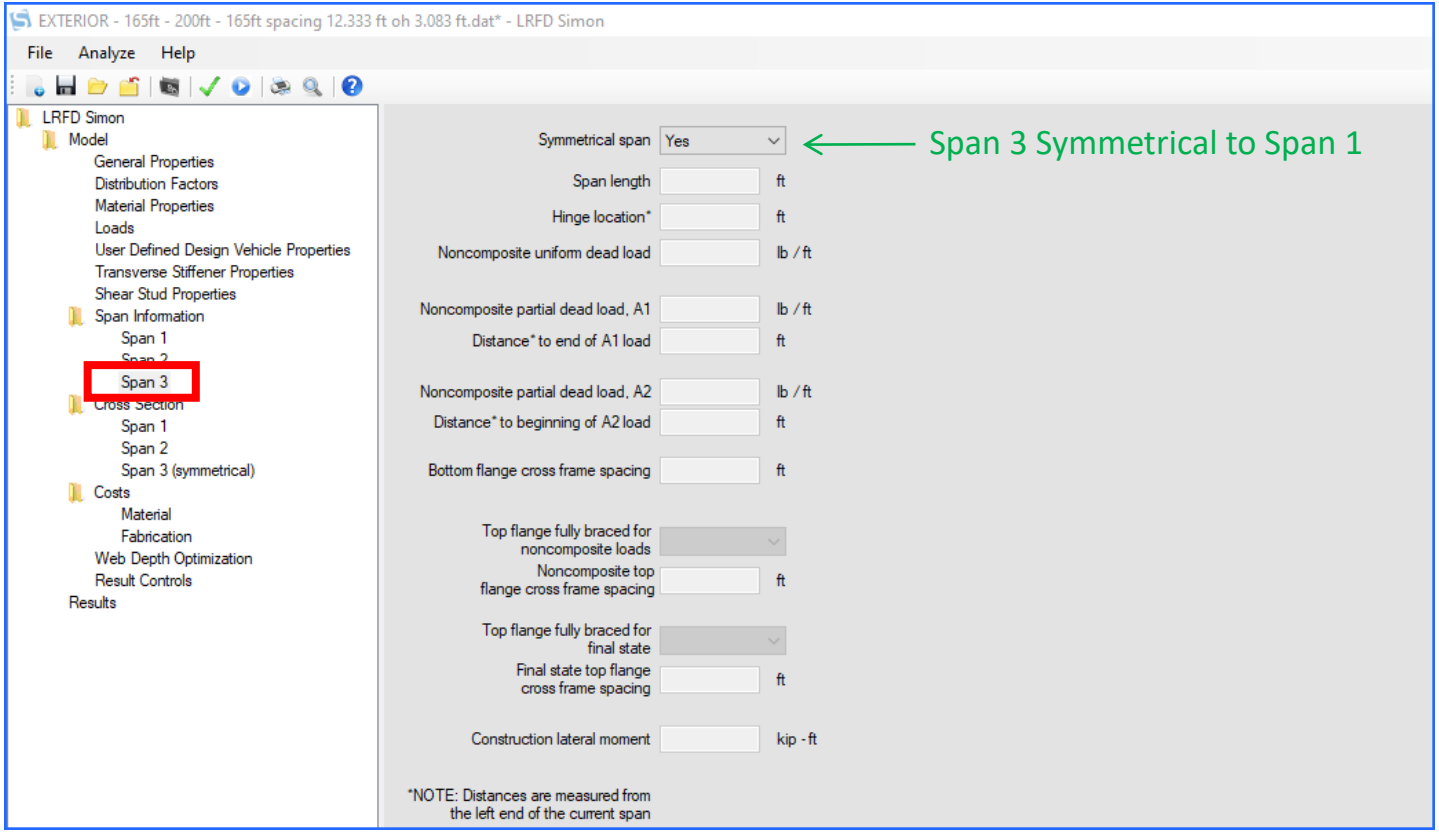
Span Information – Span 1



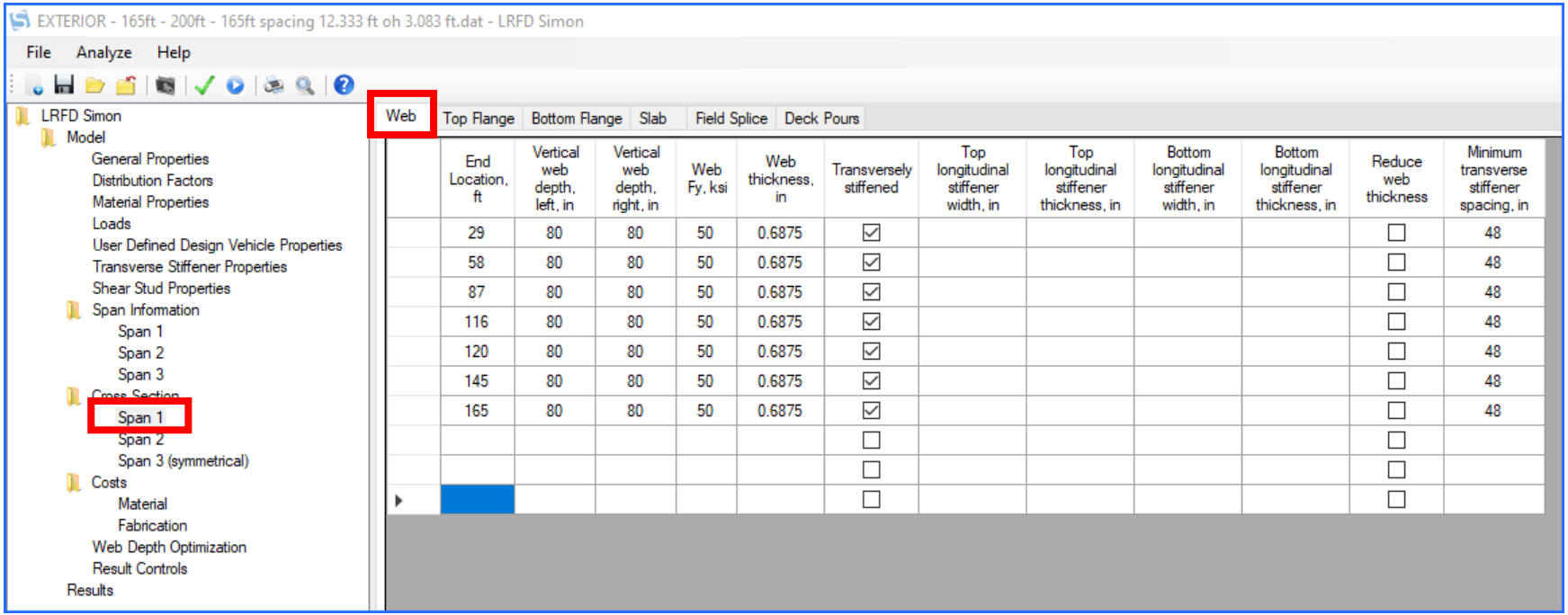
Span Information – Span 2



Span Information – Span 3

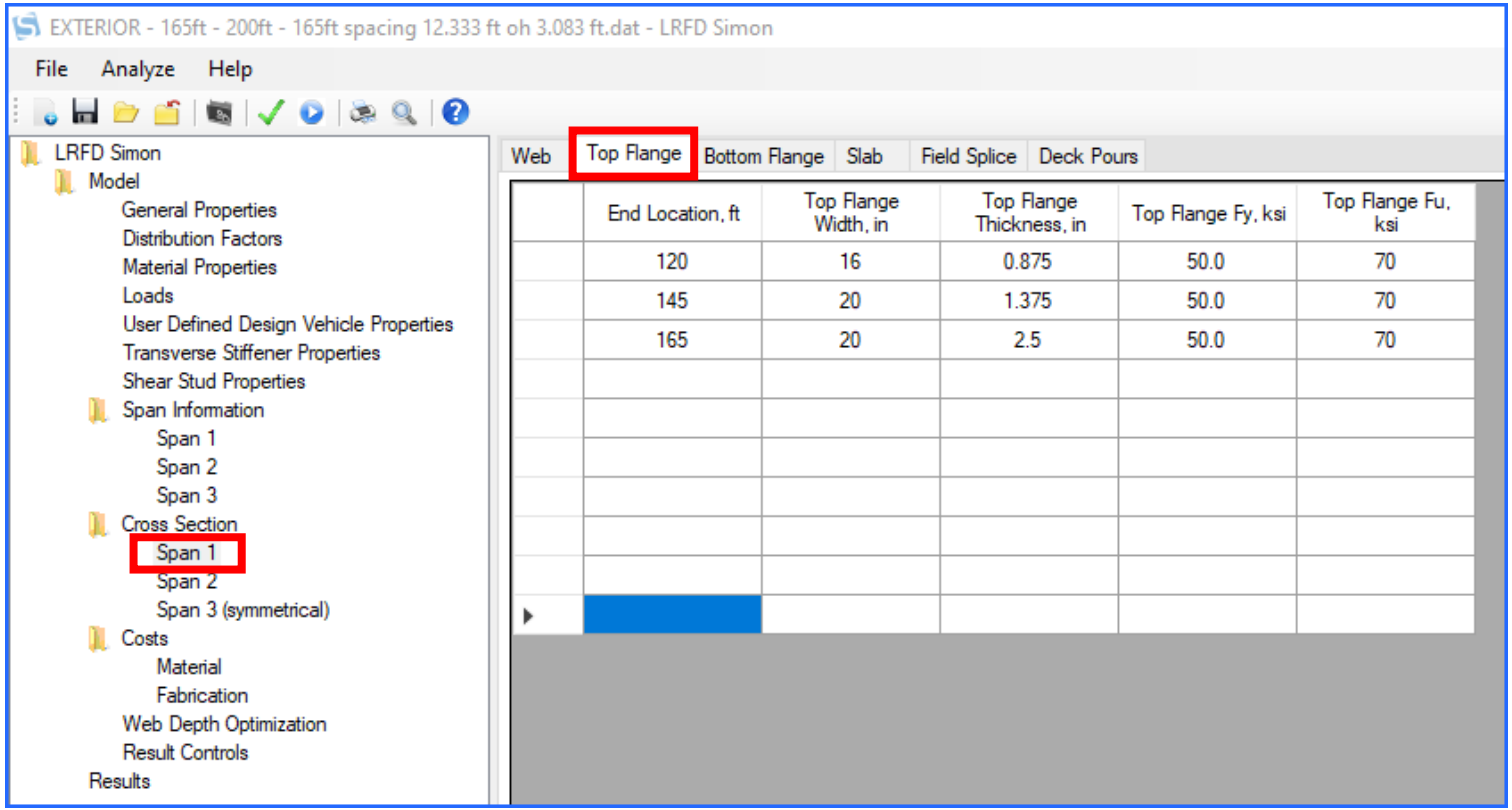


Cross Section Data – Span 1 – Web



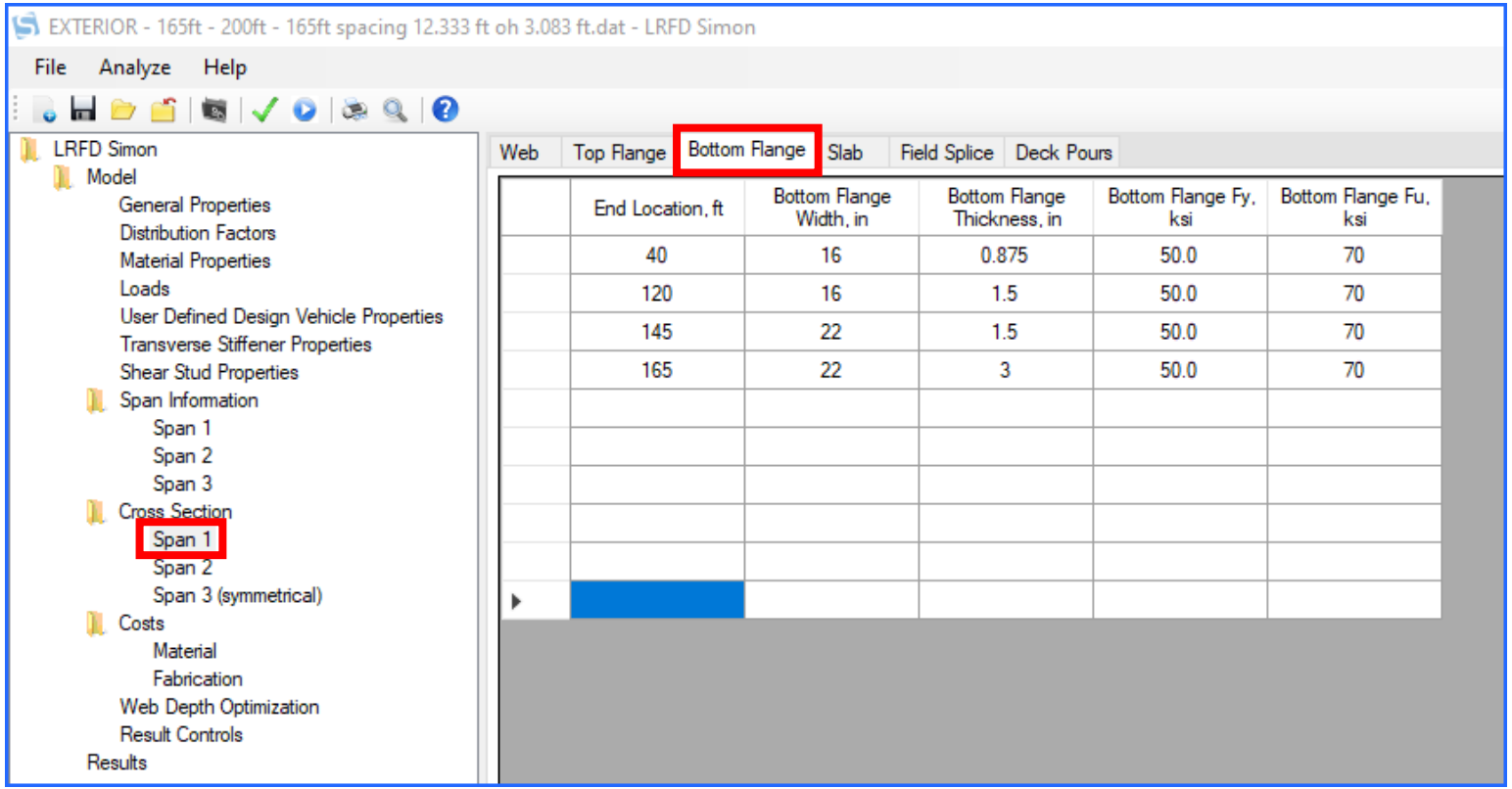
End Location, ft	Vertical web depth, left, in	Vertical web depth, right, in	Web Fy, ksi	Web thickness, in	Transversely stiffened	Top longitudinal stiffener width, in	Top longitudinal stiffener thickness, in	Bottom longitudinal stiffener width, in	Bottom longitudinal stiffener thickness, in	Reduce web thickness	Minimum transverse stiffener spacing, in
29	80	80	50	0.6875	☑					☐	48
58	80	80	50	0.6875	☑					☐	48
87	80	80	50	0.6875	☑					☐	48
116	80	80	50	0.6875	☑					☐	48
120	80	80	50	0.6875	☑					☐	48
145	80	80	50	0.6875	☑					☐	48
165	80	80	50	0.6875	☑					☐	48
					☐					☐	
					☐					☐	
					☐					☐	

Cross Section Data – Span 1 – Top Flange



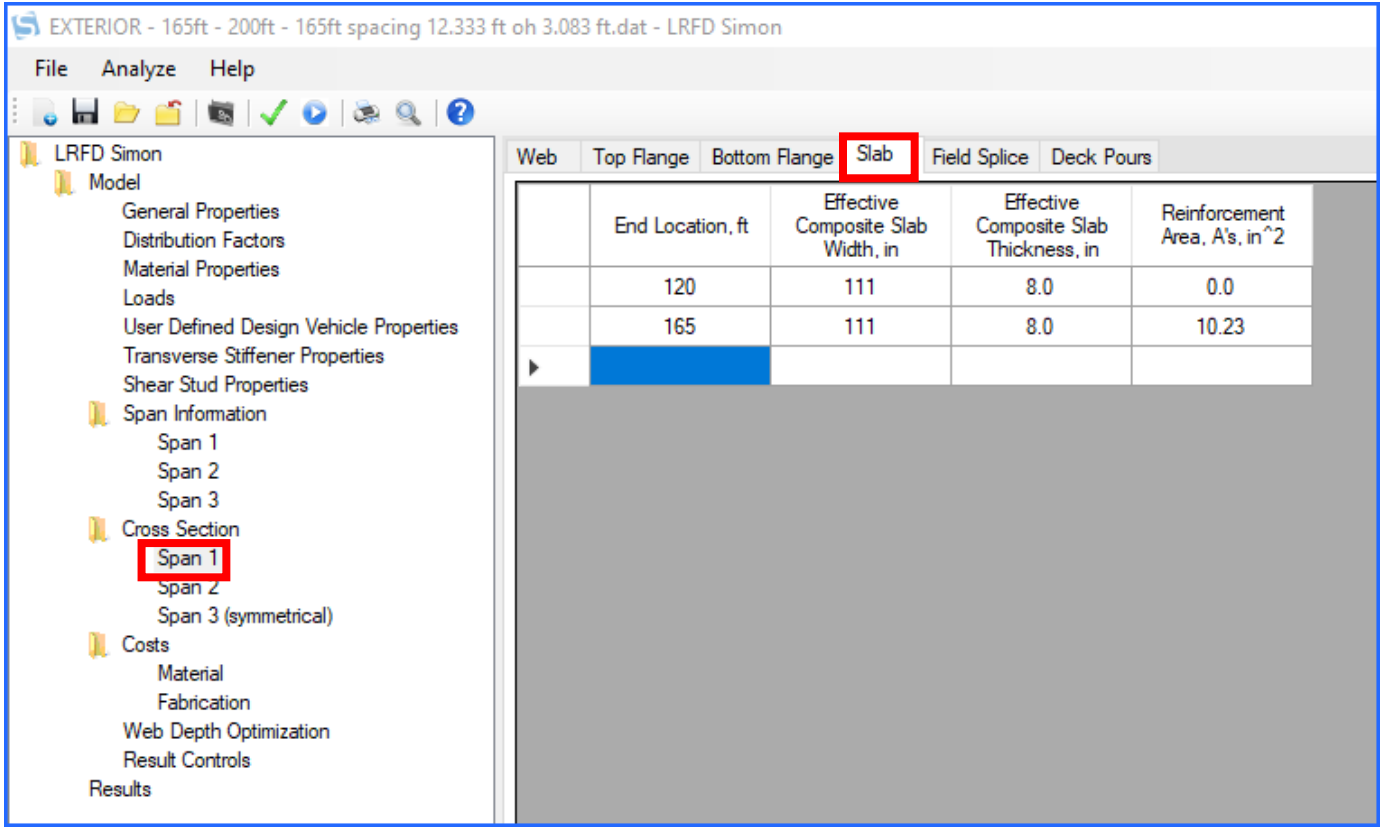
	End Location, ft	Top Flange Width, in	Top Flange Thickness, in	Top Flange Fy, ksi	Top Flange Fu, ksi
	120	16	0.875	50.0	70
	145	20	1.375	50.0	70
	165	20	2.5	50.0	70
▶					

Cross Section Data – Span 1 – Bott. Flange

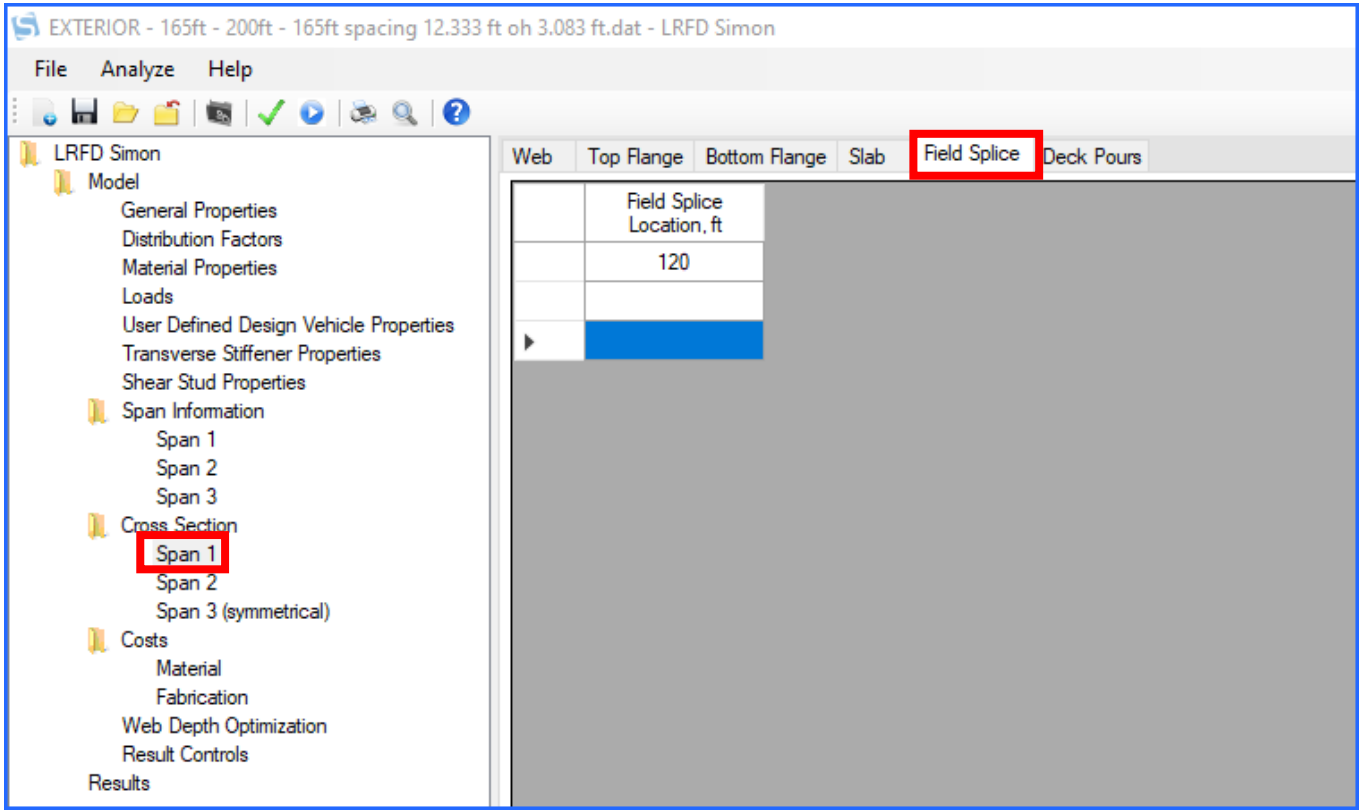


	End Location, ft	Bottom Flange Width, in	Bottom Flange Thickness, in	Bottom Flange Fy, ksi	Bottom Flange Fu, ksi
	40	16	0.875	50.0	70
	120	16	1.5	50.0	70
	145	22	1.5	50.0	70
	165	22	3	50.0	70
▶					

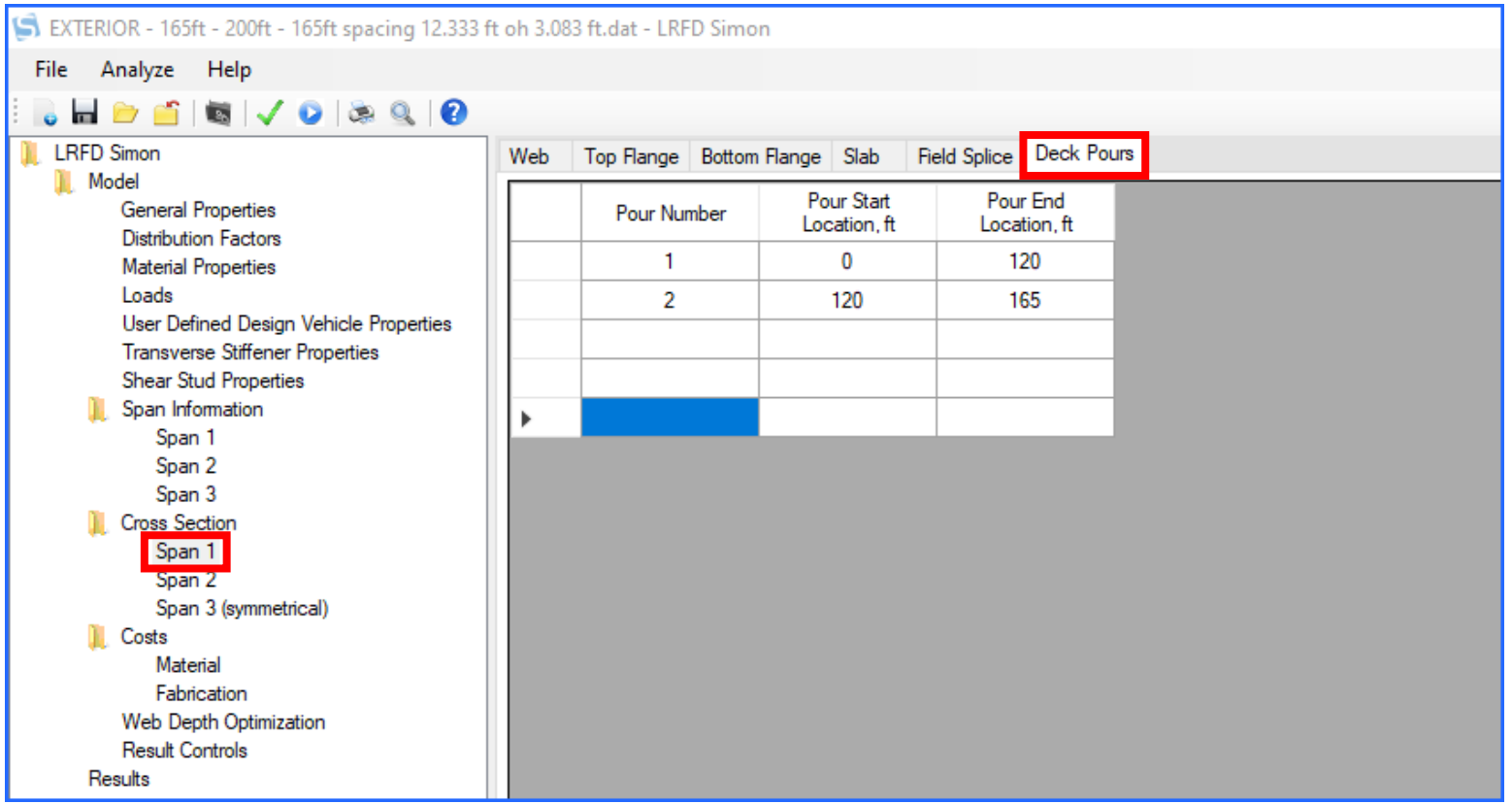
Cross Section Data – Span 1 – Deck Slab



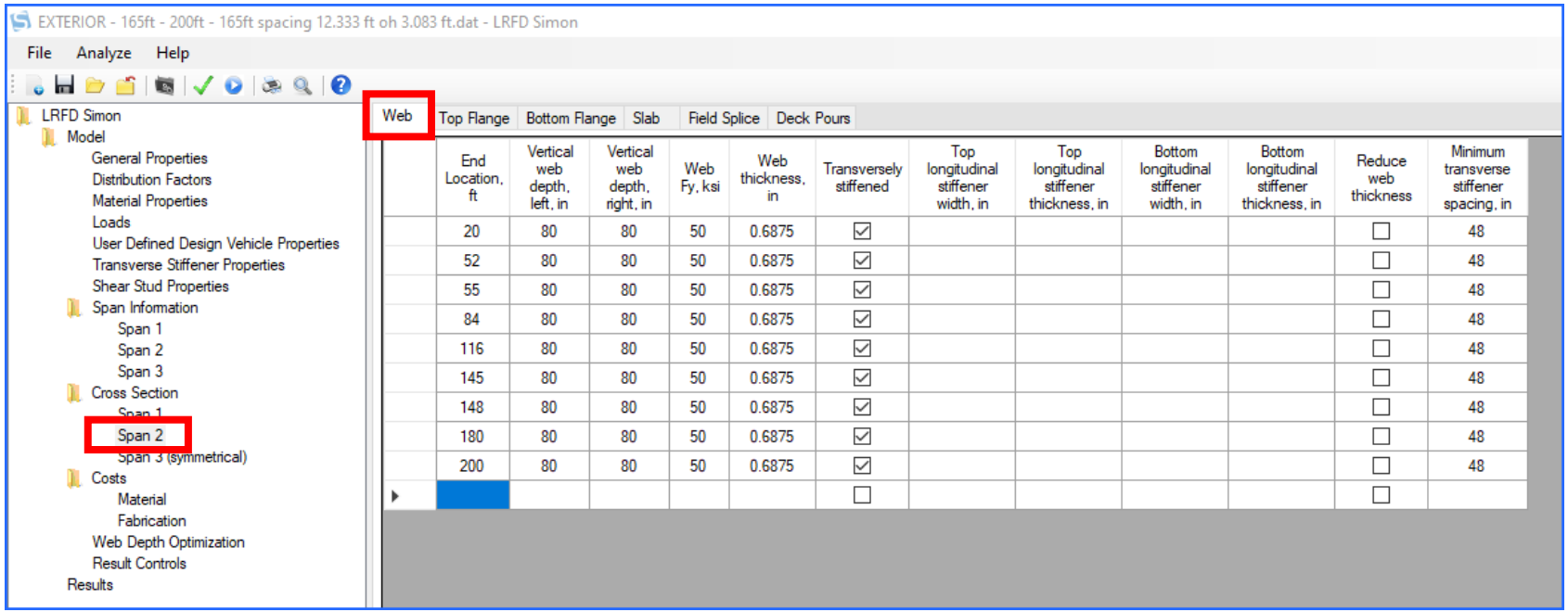
Cross Section Data – Span 1 – Field Splice



Cross Section Data – Span 1 – Deck Pours

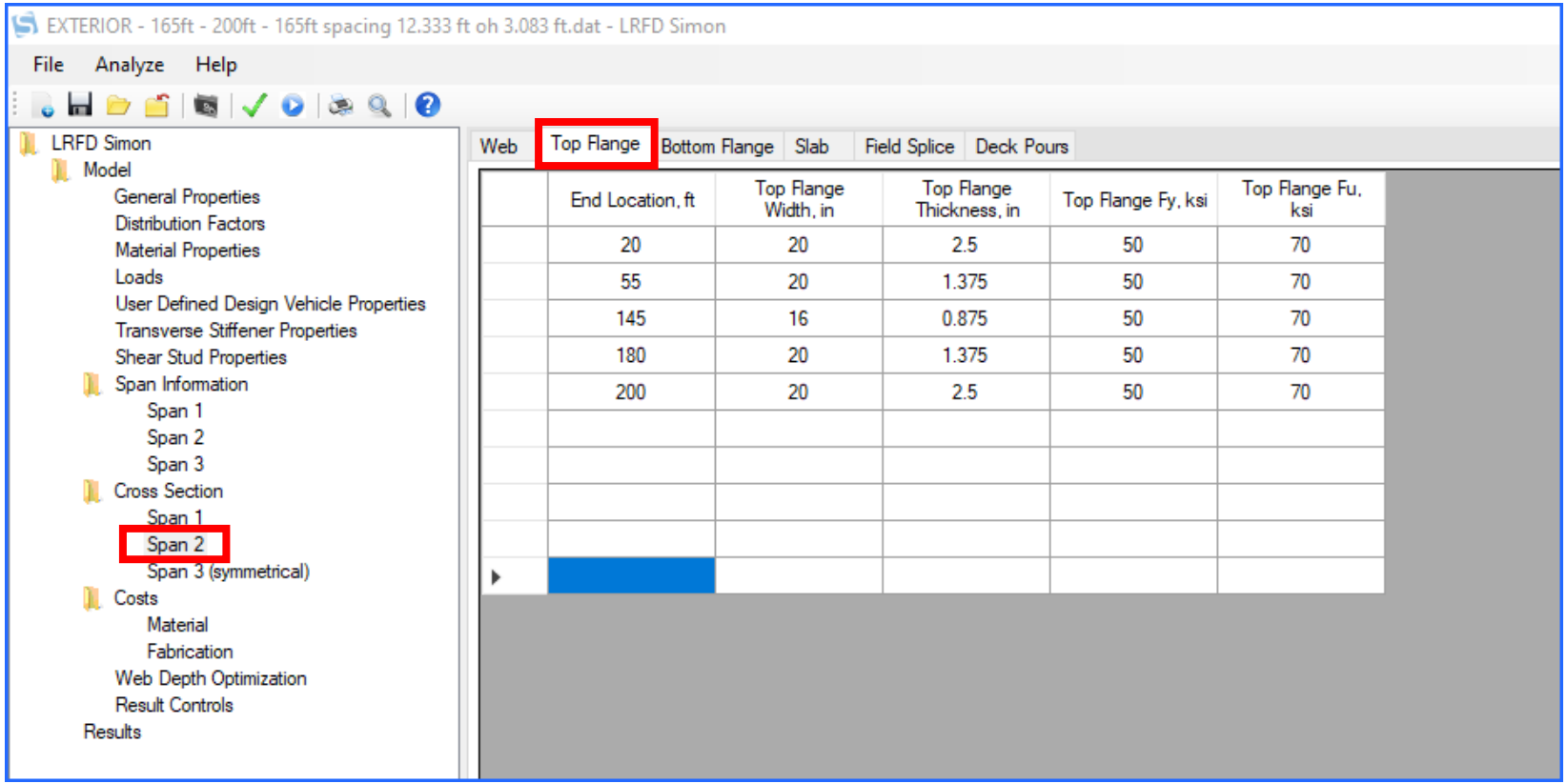


Cross Section Data – Span 2 – Web



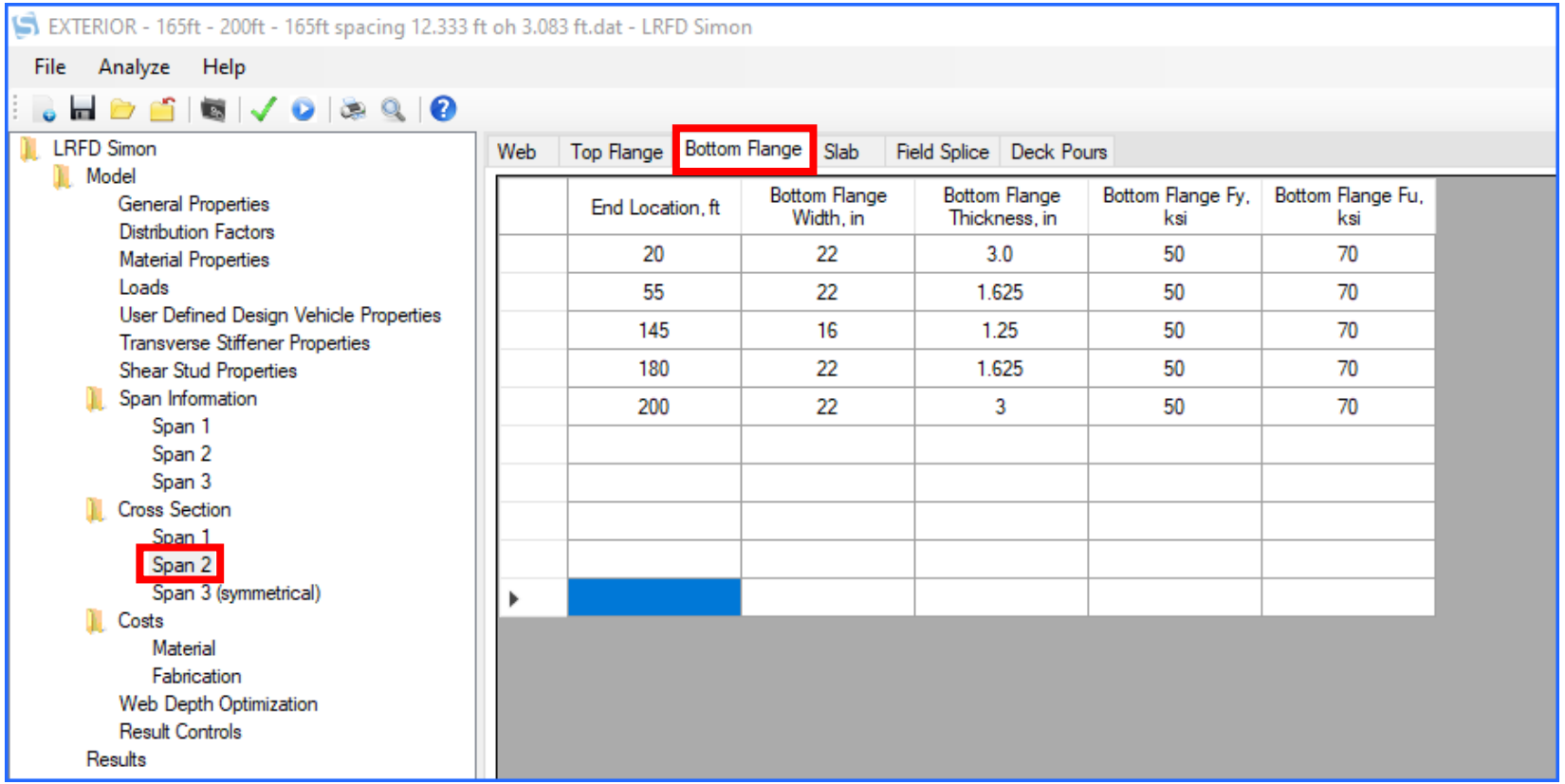
End Location, ft	Vertical web depth, left, in	Vertical web depth, right, in	Web Fy, ksi	Web thickness, in	Transversely stiffened	Top longitudinal stiffener width, in	Top longitudinal stiffener thickness, in	Bottom longitudinal stiffener width, in	Bottom longitudinal stiffener thickness, in	Reduce web thickness	Minimum transverse stiffener spacing, in
20	80	80	50	0.6875	☑					☐	48
52	80	80	50	0.6875	☑					☐	48
55	80	80	50	0.6875	☑					☐	48
84	80	80	50	0.6875	☑					☐	48
116	80	80	50	0.6875	☑					☐	48
145	80	80	50	0.6875	☑					☐	48
148	80	80	50	0.6875	☑					☐	48
180	80	80	50	0.6875	☑					☐	48
200	80	80	50	0.6875	☑					☐	48
					☐					☐	

Cross Section Data – Span 2 – Top Flange

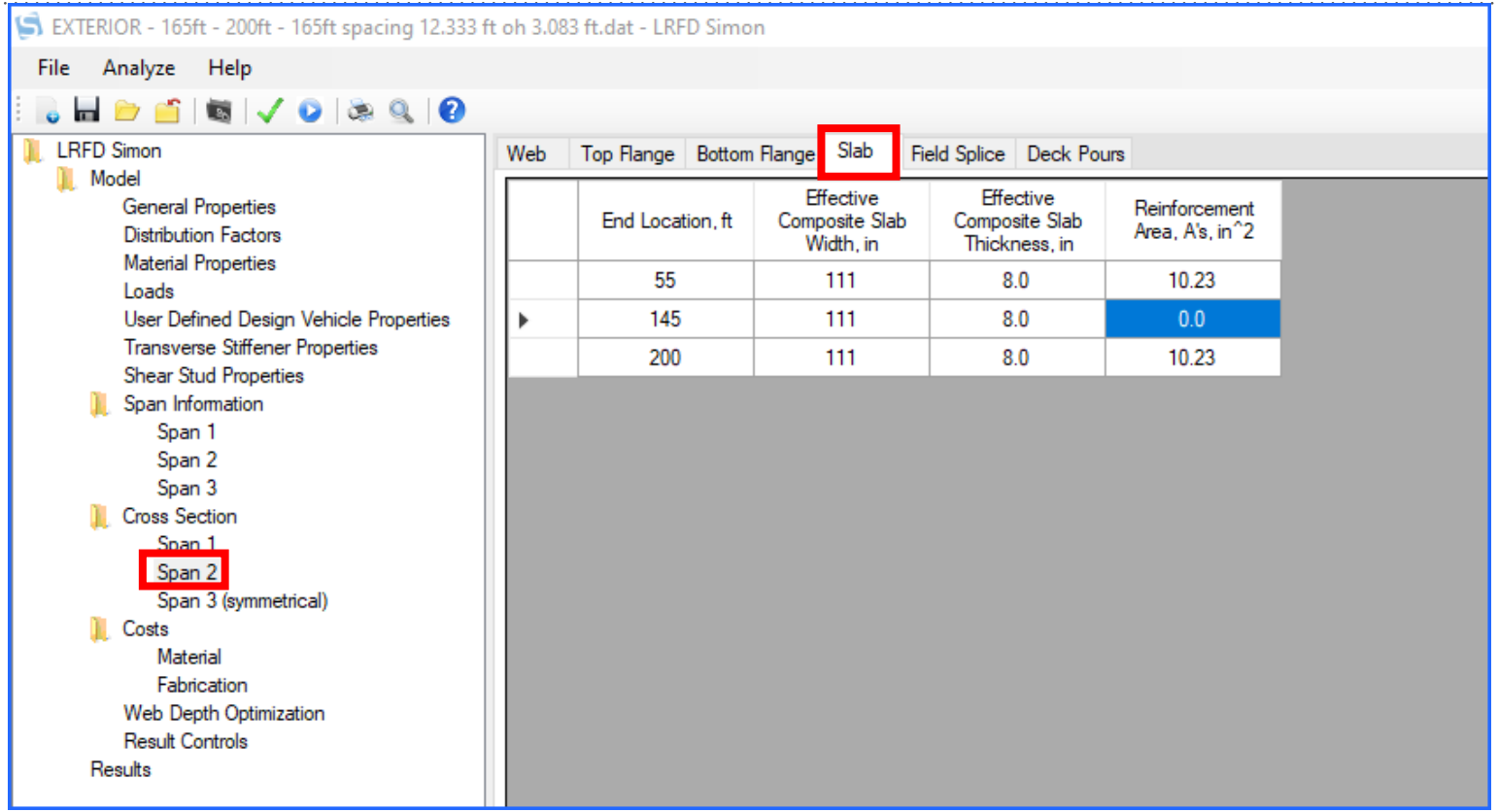


	End Location, ft	Top Flange Width, in	Top Flange Thickness, in	Top Flange Fy, ksi	Top Flange Fu, ksi
	20	20	2.5	50	70
	55	20	1.375	50	70
	145	16	0.875	50	70
	180	20	1.375	50	70
	200	20	2.5	50	70
▶					

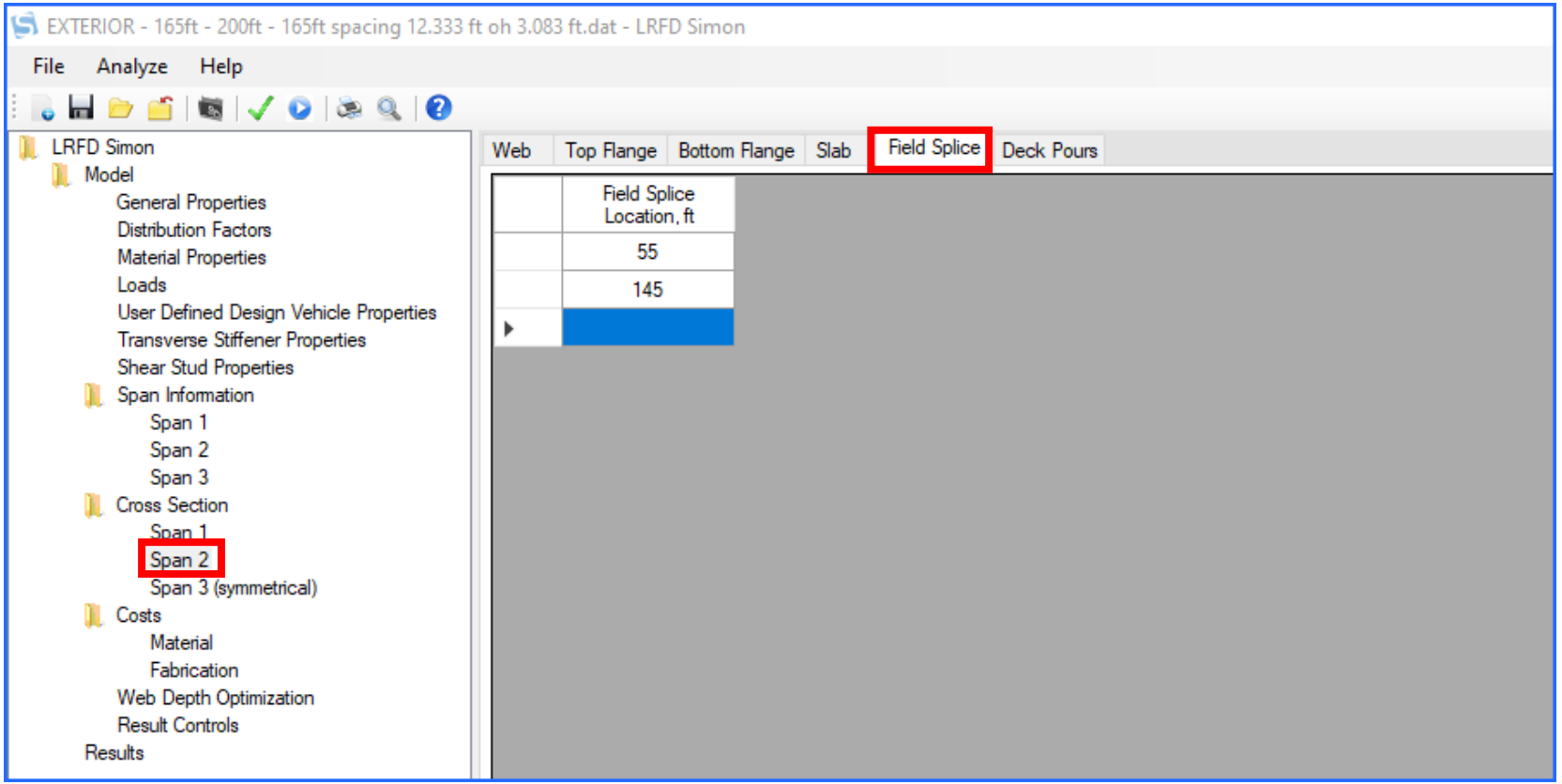
Cross Section Data – Span 2 – Bott. Flange



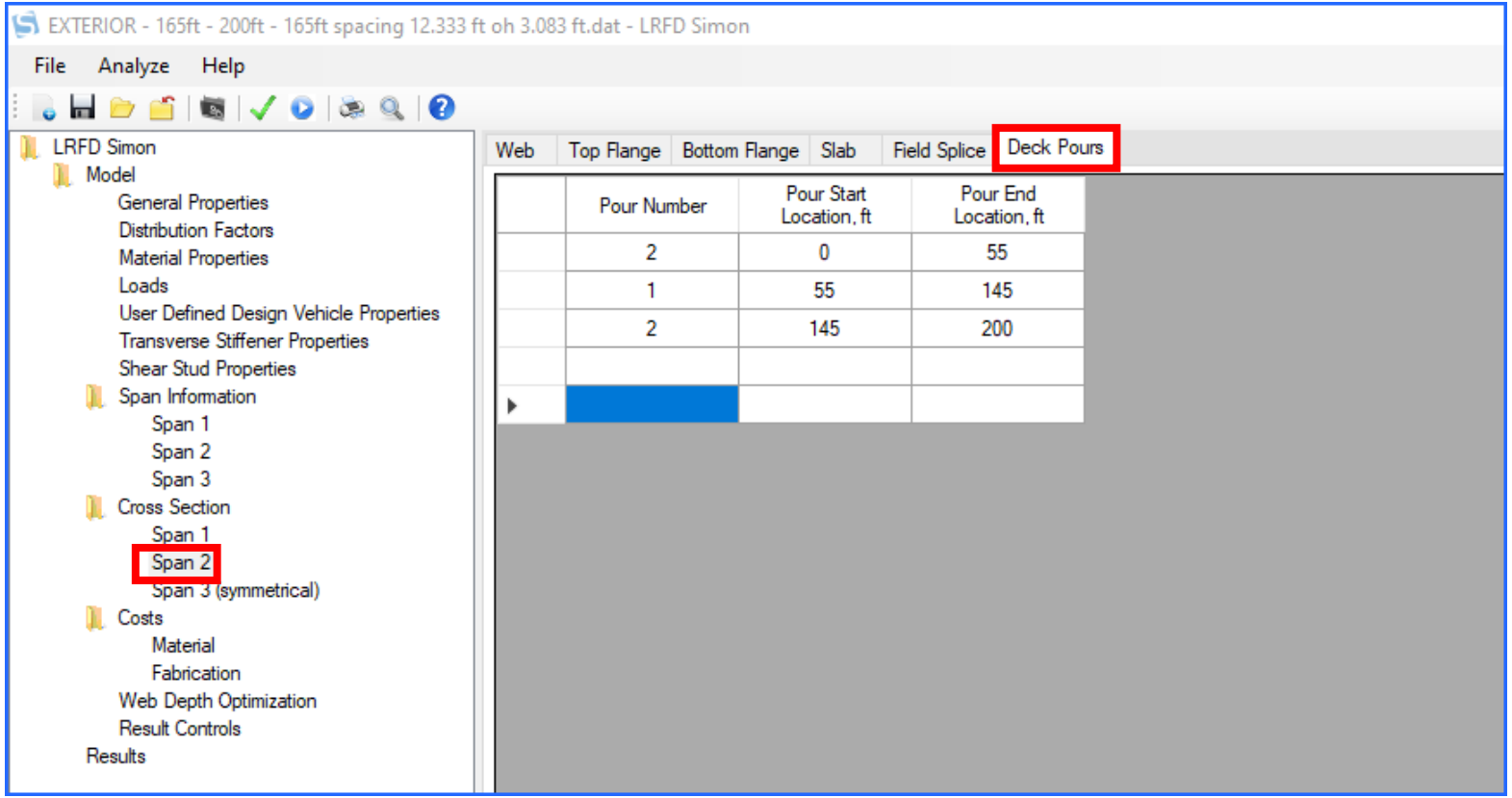
Cross Section Data – Span 2 – Deck Slab



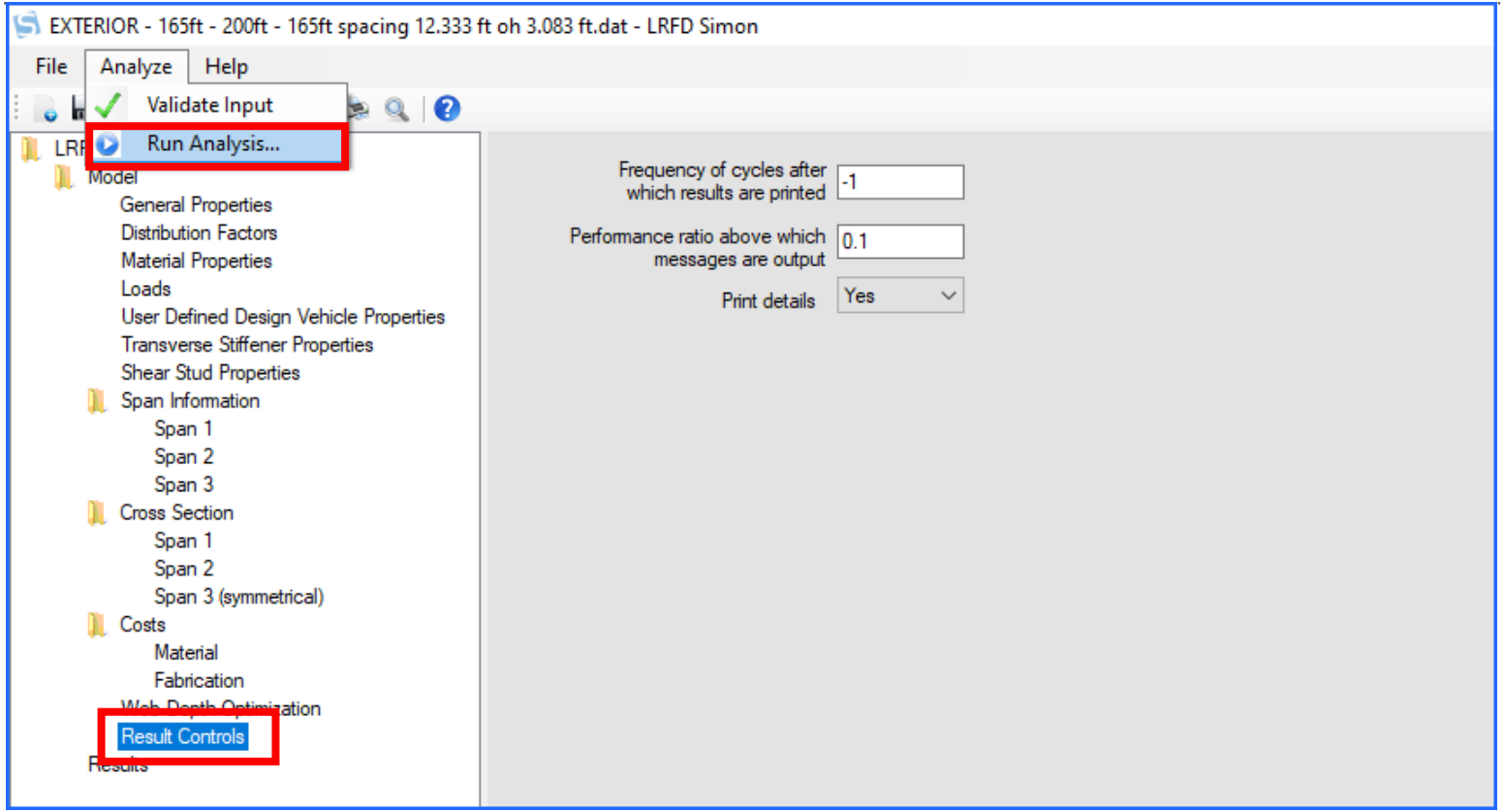
Cross Section Data – Span 2 – Field Splice



Cross Section Data – Span 2 – Deck Pours

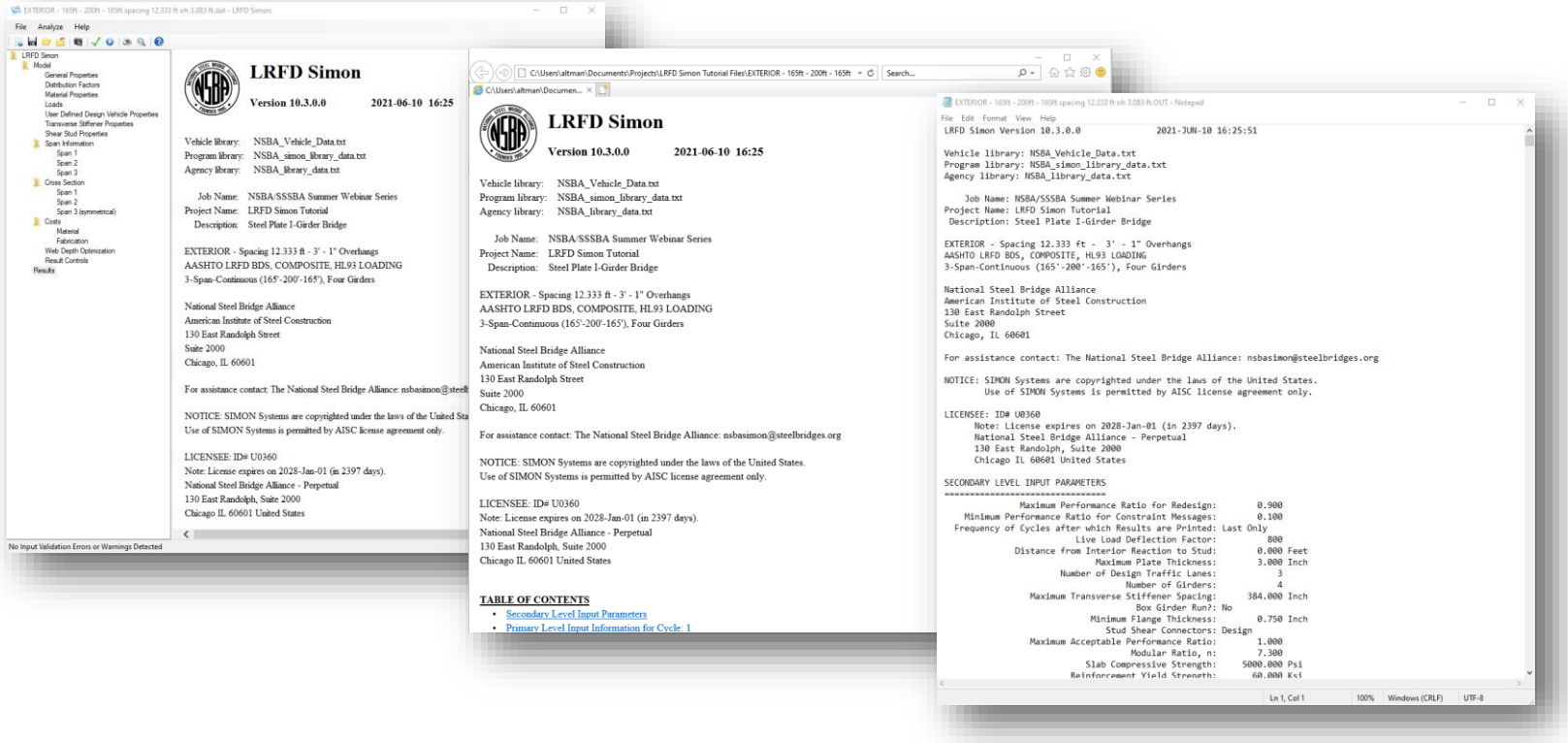


LRFD Simon – Run the Analysis



LRFD Simon – Results File

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



LRFD Simon – Results Review

Moments Results

Span: 1

Point	Girder	Other DC1	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: 2

Point	Girder	Other DC1	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

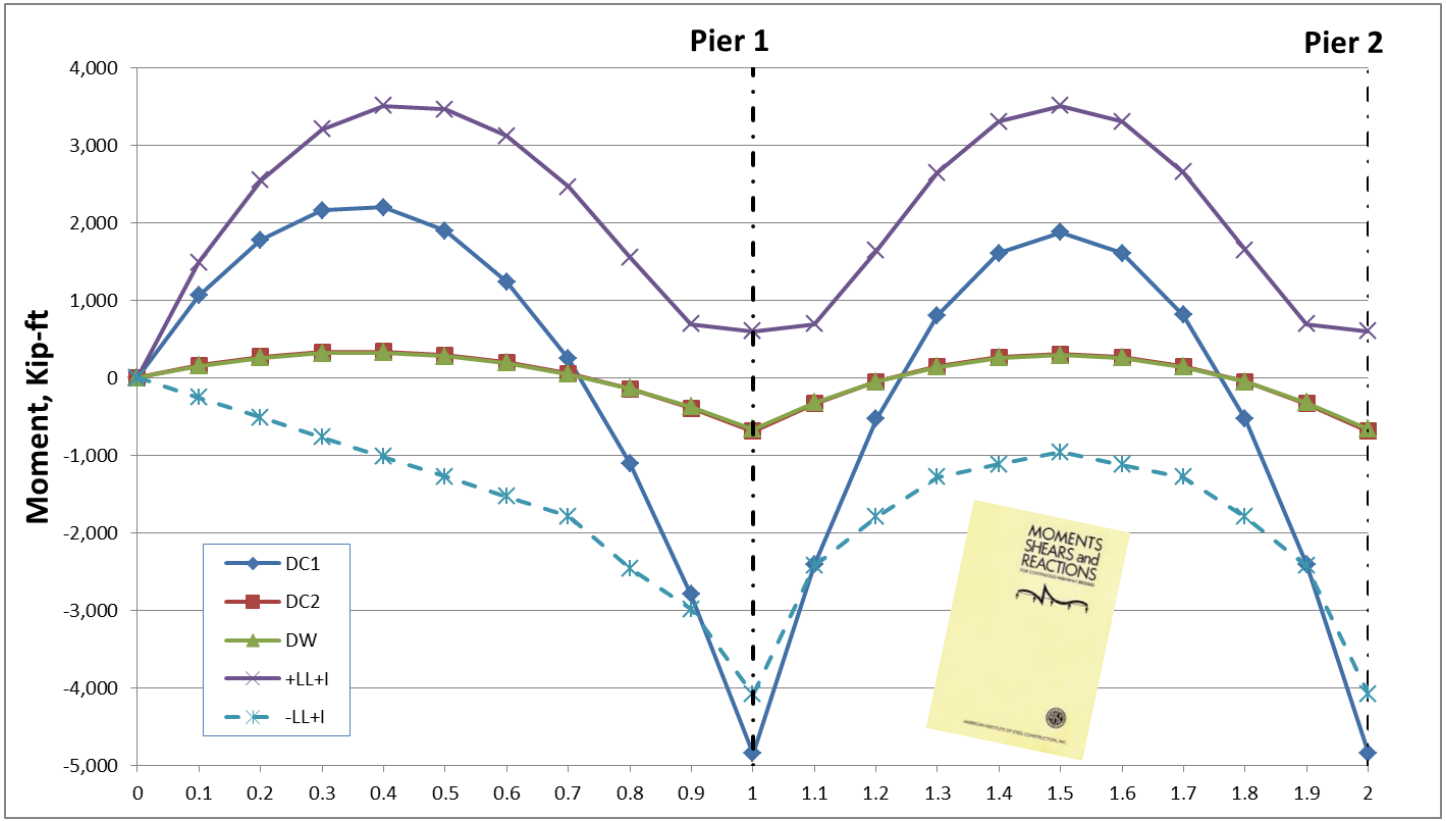
Span: 1

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	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 DC1	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: 2

Point	Girder	Other DC1	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

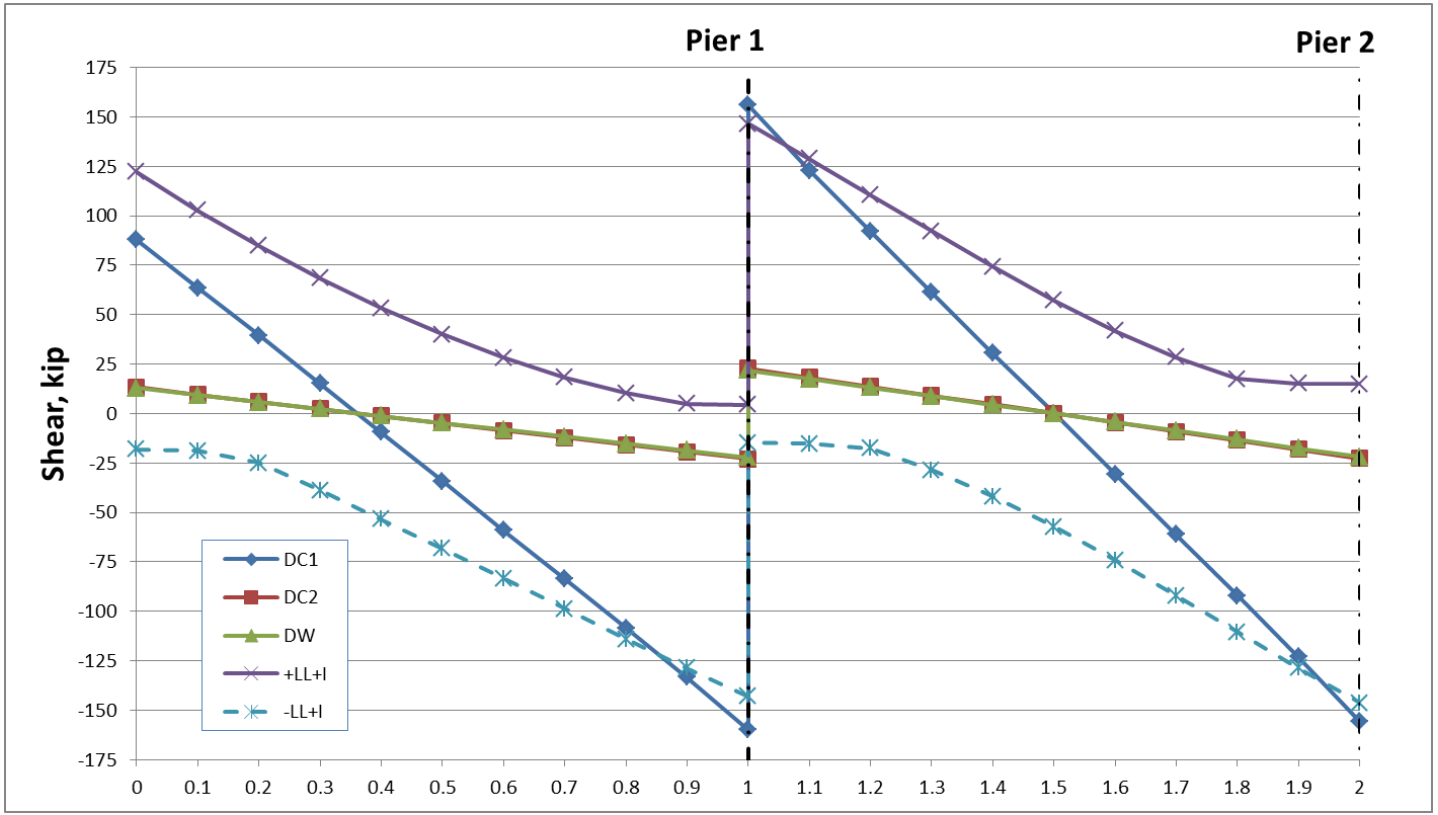
Span: 1

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

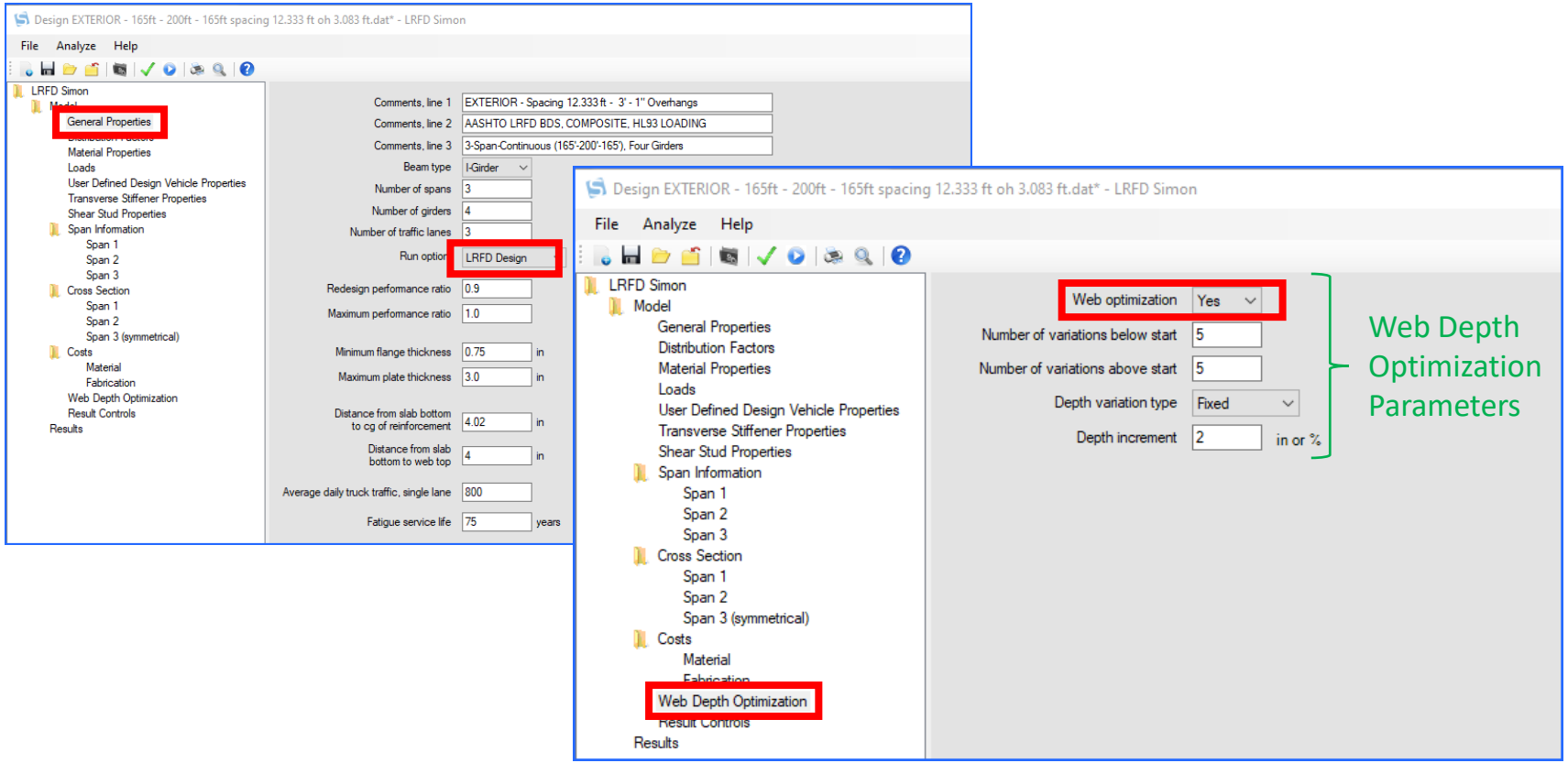
Span: 2

Point	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)



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
    - ...ntrols
  - 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, HL93 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.

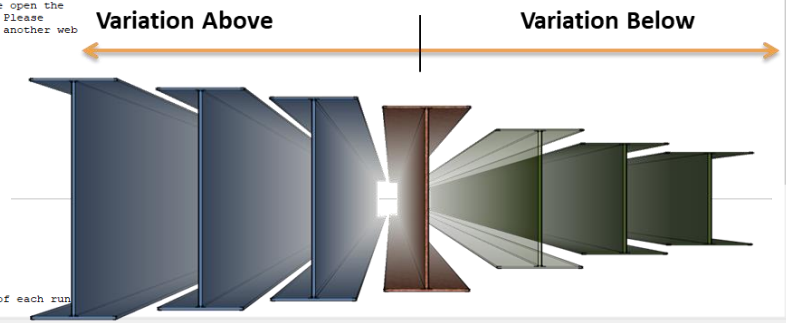
In the filenames given on the following table, BELOW designates design runs with web depths LESS than the original web depth, while ABOVE designates runs with web depths greater than the original. The numbers at the end of each of the filenames refer to the number of increments above or below the original 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 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	442957
DESIGN EXTER...H 3.083 FT	80.00	362.05	439739
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

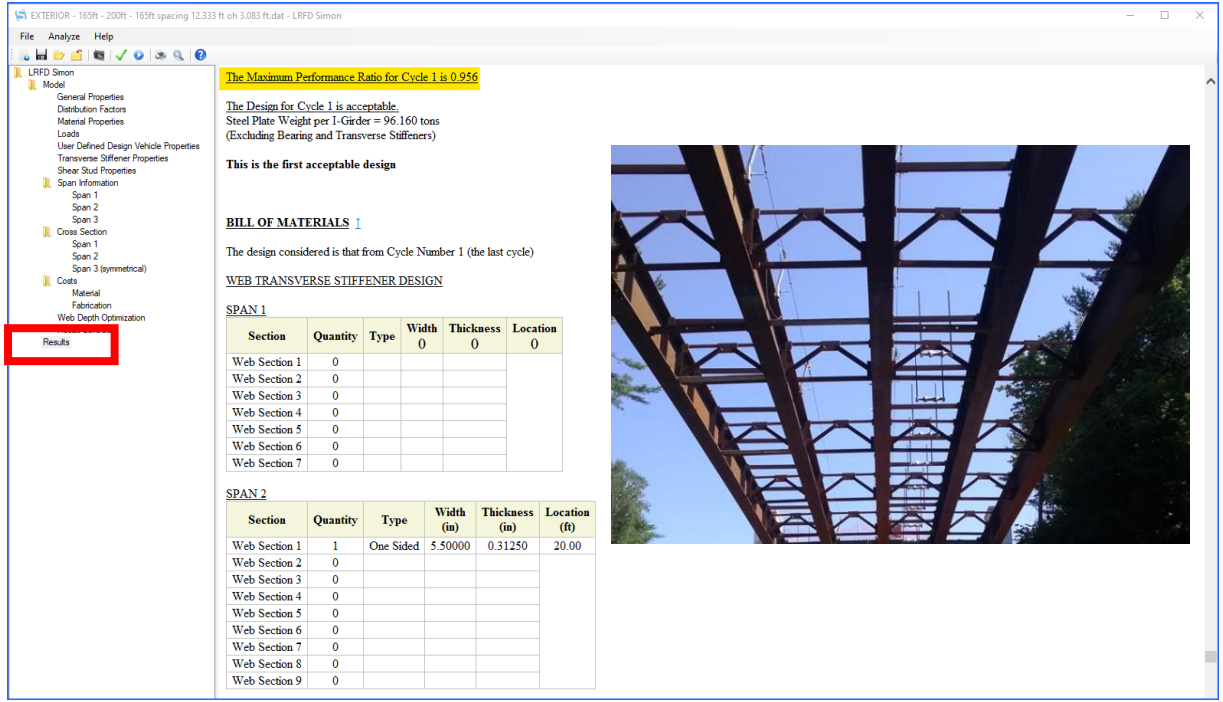


No Input Validation Errors or Warnings Detected

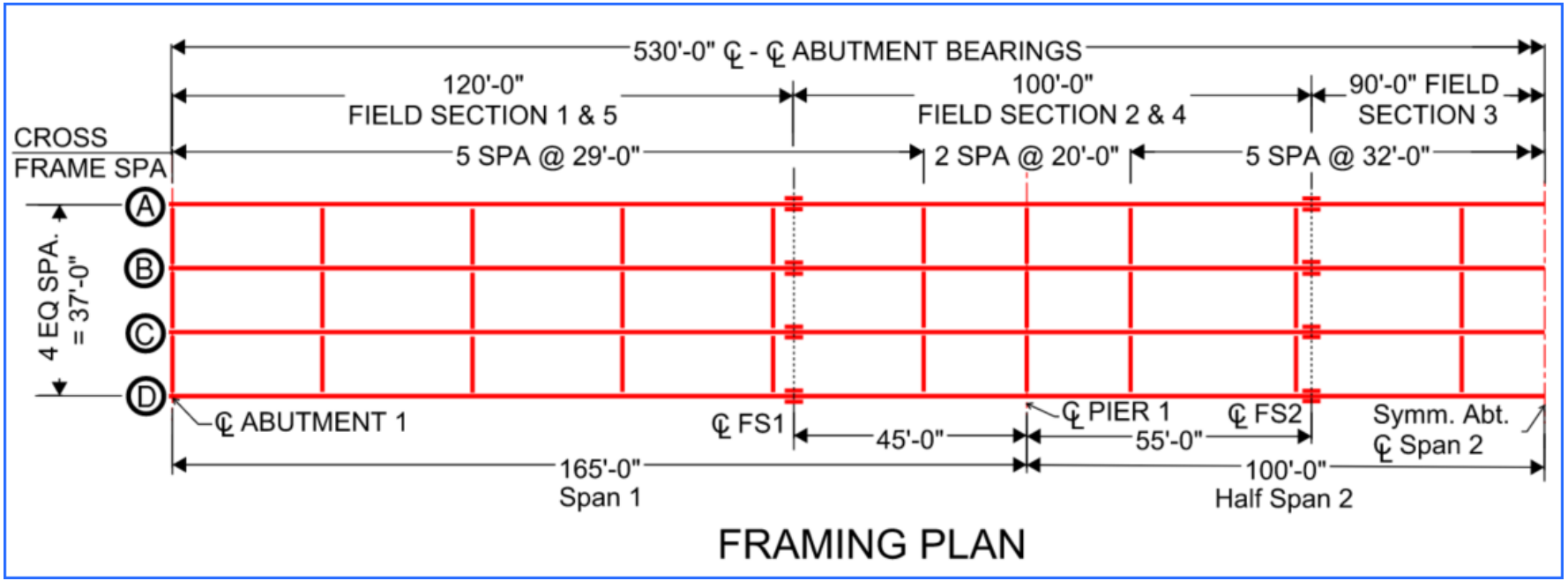
LRFD Simon – Results Review

All Performance Ratios Should Be Less Than 1.0

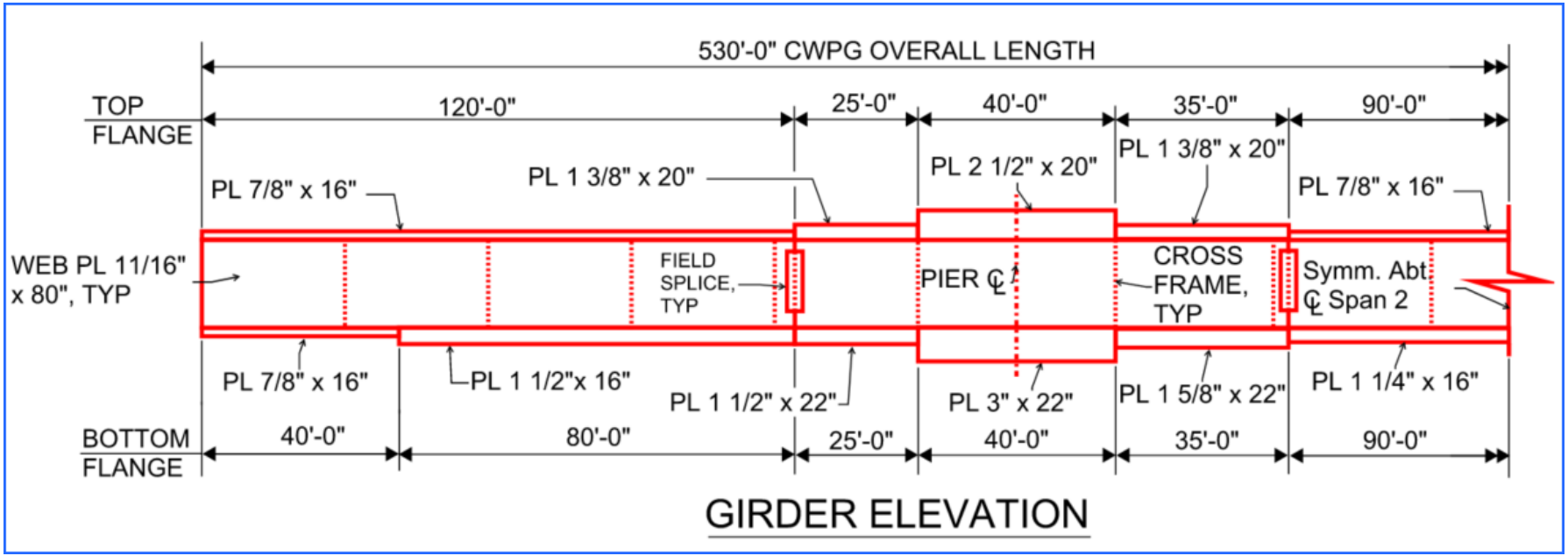
- Highest P.R. is 0.956
- Verify Interior Girder Design is Adequate
- Could Refine Further to Optimize Sections for Fabrication and Costs
- If Results P.R. More Than 1.0, Revise & Rerun
- Adjust Web Thickness and Stiffeners for Shear
- Adjust Flange Thickness & CF Locations for Flexure & Fatigue



LRFD Simon Design Results



LRFD Simon Design Results



Thank You! National Steel Bridge Alliance

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Smarter. Stronger. Steel.