Checking the LRFD Flexural-Torsional Stresses in a Steel Beam using the STAAD.pro output results:	Created By:
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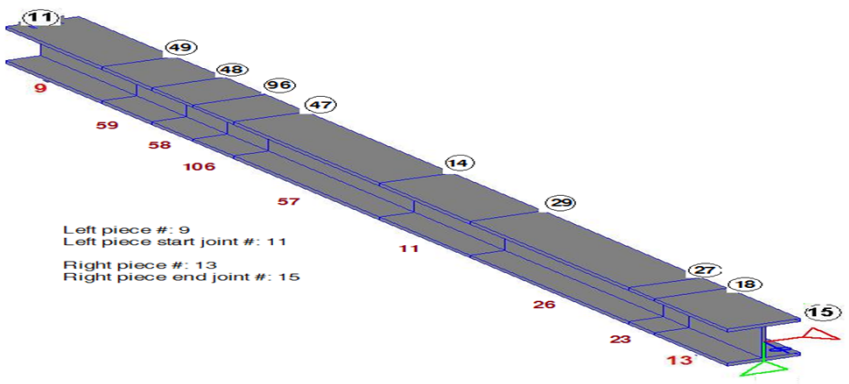
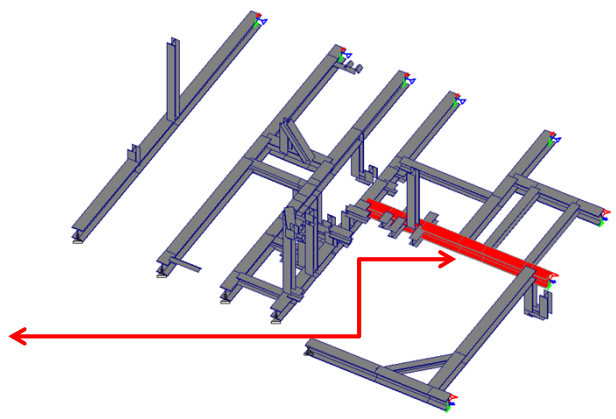
- This Excel Workbook can be used to either calculate the Torsional Stresses in a Beam(s) or it can be used to check the total LRFD (Torsional, Bending and Shear) stresses in the beam:

A - Calculating the Torsional Stresses ("Torsional Check" Worksheet)

The calculations is based on AISC's design guide #9 (LRFD) 1997-03 and the 13th edition AISC 360-05:
First, run the STAAD model with all "Strength Level" load cases included. Then copy the enveloped beams forces (all beams in the model) to worksheet "STAAD Forces" at **cell E8**.
Since, in most cases, the beam is subdivided into pieces (due to framing with other beams), in worksheet "Torsional Check", input the Beam's left end piece number and its start joint number and the Beam's right end piece number and its end joint number, as shown in the figure below:





Also,input the total beam's length, select the section property and select the torsional support condition (S for simply supported or F for fixed).
The worksheet will automatically determines the Torsional Moments in these beam's pieces (from the STAAD forces) and then "conservatively" calculates the Torsional moment in the whole beam and its location.
Then, click on the blue oval, the Torsional stresses (i.e., The Direct Torsional Shear Stresses in the Flange and the Web, The Warping Shear Stress in the Flange and the Warping Normal Stress, at the Left and Right Ends, the Center Line and at the Torsional Moment Location of the Beam) should then fill in the columns with the blue headings. The resulted torsional stresses are exactly as those obtained manually using design guide #9 charts.
The above steps can then be repeated for any beam that needs to be checked

Hints:

1 - Although a beam made up of only one segment (piece), to get the most accurate analysis, it is recommended that the beam is made up of at least 3 segments.
2 - To accurately calculate the Torsional Moment and its location in the beam from the STAAD results, it is important that (Mx) shouldn't be released at either ends of the beam.
3 - In STAAD, to specify a "Fixed" torsional end supports, add the command "SET WARP = 1.0" to the STAAD input file.

B - Calculating the Total Stresses ("Stress Check" worksheet)

Following chapter 4 of AISC's Design Guide # 9 (LRFD specifications), the Flexural, Shear and Torsional Stresses can be checked as follows:

1 - For Individual Stress checking:

* For the limit state of yielding under normal loads:

Equation 4.12:
$f_{un} \le \phi$ Fy $\phi = 0.9$ and f_{un} is the factored normal stress
Fy is the yield strength of steel

* For limit state of yielding under shear stress:

Equation 4.13:
$f_{uv} \le \phi$ (0.6 Fy) $\phi = 0.9$ and f_{uv} is the factored shear stress

* For the limit state of buckling:

Equation 4.14:
$f_{un} \le \phi_c$ Fcr_1 $\phi_c = 0.85$ and fun is the factored normal stress
fcr_1 is the critical buckling stress in compression (AISC section E3)

or

Equation 4.15:
$f_{uv} \le \phi_c$ Fcr_2 $\phi_c = 0.85$ and fuv is the factored shear stress
Fcr_2 is the critical buckling stress in shear = 0.6 Fy (AISC Equation G2-1)

2 - For Combined Stresses Checking:

Interaction of Normal Stresses can be checked using equation 4.16b of the design guide as follows:

$$\frac{\sigma_a}{0.85F_{cr,1}} \pm \frac{\sigma_{bx}}{\left(1-\frac{P_u}{P_{ex}}\right)\phi_b F_{cr,3}} \pm \frac{\sigma_{by}}{\left(1-\frac{P_u}{P_{ey}}\right)0.9F_y} \pm \frac{\sigma_w}{\left(1-\frac{P_u}{P_{ey}}\right)0.9F_y} \le 1.0$$

where:

σ_a = Factored Axial Stress

σ_{bx} = Factored Strong Axis Bending Stress

σ_{by} = Factored Weak Axis Bending Stress

σ_w = Factored Normal Stress due to Warping

Fcr_3 = minimum of [Fy or Fcr,elastic (AISC equation F2-4)]

Pu = Factored Axial Force

Pex and Pey are the Euler Buckling Loads in the Strong and Weak axes, rspectively

3 -Checking Procedure:

* After executing the steps explained in part A above, each beam can be investigated for LRFD stress checking as follows:
  - In worksheet "Stress Check", input the information required in the yellow highlighted cells.
    For the beam under consideration, you need to input all the members (pieces) numbers that connect the whole beam together as well as their starting and ending joint numbers and their lengths and shapes (**see picture below** for filling the members information for the beam **shown in the above picture**)
  - The worksheet will automatically import any additional required information from the other worksheets and complete the checking procedure as shown in parts B-1 and above B-2
  - The worksheet will also show the status of the design of the beam according to the checkings performed and will state if the beam design is safe or not.

Start here

Loaded point laterally unrestrained: 1

Fy =	50.000	ksi
Fu =	65.000	ksi
E =	29000.000	ksi
Lx =	11.580	ksi
Ly =	6.000	ft
C_b =	1.000	
h_o =	7.815	in.
C =	1.000	
Cw =	931.000	in^6
Iy =	60.900	in^4
Sx =	43.200	in^3

IN THE YELLOW CELLS BELOW, INPUT ALL THE PIECES INFORMATION THAT ARE PART OF THE BEAM UNDER CONSIDERATION (AS EXPLAINED IN INSTRUCTIONS):

Note: Starting and end member no.s should match that in "Torsional Check" sheet

Piece #	Member Number	Member Start Joint #	Member End Joint #	Member Length (ft)	Beam Size
1	9	11	49	1.54	W8X48
2	59	49	48	0.80	W8X48
3	58	48	96	0.66	W8X48
4	106	96	47	0.65	W8X48
5	57	47	14	2.35	W8X48
6	11	14	29	1.46	W8X48
7	26	29	27	2.54	W8X48
8	23	27	18	0.42	W8X48
9	13	18	15	1.17	W8X48
10					
11					
12					

Copy the STAAD Members
Enveloped forces to E8 to M8

Beam	Node	Env	Fx kip	Fy kip	Fz kip	Mx kip-ft	My kip-ft	Mz kip-ft	Mz kip-ft
1	1	+ve	0	7.649	0	0	0	0	
			22049 1.2 (	22049 1.2 (	-	-	-	25044 (1.2 + 0.2 SDS) * D + RHO(-EZ + 0.3 -I	
		-ve	0	0	0	0	0	0	
			23001 1.2 I	-	-	-	-	23019 1.2 D + 1.6 S - 0.8WZ + 0.4 WX	
1	94	+ve	0	2.968	0	0	0	0	
			22049 1.2 (	22009 1.2 (	-	-	-	-	
		-ve	0	0	0	0	0	-32.65	
			23001 1.2 I	-	-	-	-	22049 1.2 (D) + 1.6 L(NO OPERATION) + 1.	
2	3	+ve	1.462	12.968	0.384	0	0	0	
			25028 (1.2	22049 1.2 (	26008 0.9 I	22049 1.2 (	24019 1.2 I	24022 1.2 D + 1.6 (-WZ - 0.5WX) + 1.0 L (NO	
		-ve	-0.653	0	-0.639	0	0	0	
			27009 (0.9	-	24015 1.2 I	23016 1.2 I	25034 (1.2	23009 1.2 D + 1.6 S + 1.0 L (MAX DOWN)	
2	107	+ve	1.462	12.002	0.384	0	0.364	0	
			25028 (1.2	22049 1.2 (	26008 0.9 I	22049 1.2 (	26008 0.9 I	-	
		-ve	-0.653	0	-0.639	0	-0.606	-11.836	
			27009 (0.9	-	24015 1.2 I	23016 1.2 I	24015 1.2 I	22049 1.2 (D) + 1.6 L(NO OPERATION) + 1.	
3	5	+ve	0.94	10.674	0.826	0	0	0	
			24011 1.2 I	22049 1.2 (	25044 (1.2	25042 (1.2	27005 (0.9	24003 1.2 D + 1.6 (WX + 0.5WZ) + 1.0 L (MA	
		-ve	-0.639	0	-0.513	0	0	0	
			26001 0.9 I	-	27013 (0.9	27003 (0.9	24012 1.2 I	24021 1.2 D + 1.6 (-WZ + 0.5WX) + 1.0 L (MA	
3	34	+ve	0.94	9.54	0.826	0	1.191	0	
			24011 1.2 I	22049 1.2 (	25044 (1.2	25042 (1.2	25044 (1.2	-	
		-ve	-0.639	0	-0.513	0	-0.74	-14.574	
			26001 0.9 I	-	27013 (0.9	27003 (0.9	27013 (0.9	22049 1.2 (D) + 1.6 L(NO OPERATION) + 1.	
4	7	+ve	0.196	17.54	0.605	0	0	0	
			27019 (0.9	22049 1.2 (	24021 1.2 I	24024 1.2 I	24024 1.2 I	22009 1.2 (D + T) + 1.6 L(MAX DOWN) + 0.5	
		-ve	-0.614	0	-0.607	0	0	0	
			25018 (1.2	-	24016 1.2 I	25070 (1.2	25036 (1.2	22001 1.2 (D + T) + 1.6 L(NO OPERATION) +	
4	44	+ve	0.196	16.104	0.605	0	0.873	0	
			27019 (0.9	22049 1.2 (	24021 1.2 I	24024 1.2 I	24021 1.2 I	-	
		-ve	-0.614	0	-0.607	0	-0.875	-24.257	
			25018 (1.2	-	24016 1.2 I	25070 (1.2	24016 1.2 I	22049 1.2 (D) + 1.6 L(NO OPERATION) + 1.	
5	9	+ve	0.489	0	0.577	3.866	3.597	0	

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		/ / 20	1 2
		Originator:	
		Reviewer:	
CLIENT NAME:		CALC NO.:	
PROJECT NAME:		JOB NO.:	

CALCULATE

Fill all the yellow highlighted cells and then hit "calculate" button to view the Torsional Stresses

											MAX Torsional Stresses (ksi)											
											Top Flange - Direct Torsional Shear Stress (F-τ_t)				Web - Direct Torsional Shear Stress (W-τ_t)				Top Falnge - Warping Shear Stress (τ_w)				Top Flange - Warping Normal Stress (σw)			
Start Beam #	**End Beam #**	**Beam Start Joint #**	**Beam End Joint #**	**Total Member Length (ft)**	**Select Beam Size**	**Torsional End Fixity Simple "S" or Fixed "F"**	**Start**	**End**	**Design Torsion (ft-kip)**	**x (ft)**	**L. Support**	**Mid Span**	**Load**	**R. Support**	**L. Support**	**Mid Span**	**Load**	**R. Support**	**L. Supp.**	**Mid Span**	**Load**	**R. Support**	**L. Supp.**	**Mid Span**	**Load**	**R. Support**
9	**13**	**11**	**15**	**11.58**	W8X48	S	9-11	13-15	1.67	3.41	2.77	-0.63	1.11	-1.68	1.62	-0.37	0.65	-0.98	0.21	-0.14	0.38	-0.04	0.00	-2.35	-5.38	0.00

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Start here

Loaded point laterally unrestrained	1

Fy =	50.000	ksi
Fu =	65.000	ksi
E =	29000.000	ksi
Lx =	11.580	ft
Ly =	6.000	ft
C_b =	1.000	
h_0 =	7.815	in.
C =	1.000	
Cw =	931.000	in^6
Iy =	60.900	in^4
Sx =	43.200	in^3
r_{ts} =	2.348	in
J =	1.960	in^4
L_b/r_{ts} =	30.668	
pi =	3.143	
$C_b.pi^2.E$ =	2.864E+05	
$J.C/S_x.h_0$ =	5.806E-03	
$F_{cr,elastic}$ =	3.637E+02	ksi
σbx =	9.492	ksi
Ix =	184.000	in^4
Sy =	15.000	in^3
Aw =	3.400	in^2
Af =	5.555	in^2

Amplification	1.030

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8	23	27	18	0.42	W8X48
9	13	18	15	1.17	W8X48
10					
11					
12					

Fx=	0.89	Vy=	-9.98	Vz =	0.26	My=	0.13	Mz =	-34.17

A =	14.10		
σ_a = Fx/A =	0.06	ksi	

σbx =	9.49	ksi
σby =	0.10	ksi

Kx =	1.00	rx =	3.61	in
Ky =	1.00	ry =	2.08	in
KxLx/rx =	38.49			
KyLy/ry =	34.62	KL/r =	38.49	

4.7*(√(E/fy))=	113.19
Fe =	193.32
Fy/Fe =	0.26
Cv =	1.00

Fcr,1 =	44.87	ksi	Pe,y =	3.37E+03	kips
Fcr,2 =	30.00	ksi	Pe,x =	2.73E+03	kips
Fcr,3 = min(F_y, $F_{cr,elastic}$) =				50.00	ksi

σu,n =	15.21	ksi
τu,w =	4.55	ksi
τu,f =	3.17	ksi

1 -Check Interaction of Individual Stresses

Check-1 =	σu,n/(0.9Fy)=	0.34	Good
Check-2 =	τu,w/(0.9*(0.6Fy))	0.17	Good
Check-3 =	τu,f/(0.9*(0.6Fy))	0.12	Good
Check-4 =	σu,n/(o.9*Fcr,1)	0.38	Good
Check-5 =	τu,w/(0.9Fcr,2)	0.17	Good

Results from Torsional Check Sheet for the above beam:

Absolute max. Direct Flange Torsional shear stress=	2.77	
Absolute max. Direct Web Torsional shear stress=	1.62	
Absolute max. Direct Flange Warping shear stress=	0.38	
Absolute max. Direct Flange Warping Normal stress=	5.38	
Torsional Rotation at Mid-Span (Degrees) =	0.71	Good
Torsional Rotation at Load (Degrees) =	0.69	Good

2 - Check Interaction of combined Stresses:

$$\frac{\sigma_a}{0.85F_{cr,1}} \pm \frac{\sigma_{bx}}{\left(1-\frac{P_u}{P_{ex}}\right)\phi_b F_{cr,3}} \pm \frac{\sigma_{by}}{\left(1-\frac{P_u}{P_{ey}}\right)0.9F_y} \pm \frac{\sigma_w}{\left(1-\frac{P_u}{P_{cy}}\right)0.9F_y} \leq 1.0$$

= 0.338 Good