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:
     \[ f_{un} \leq \phi \cdot F_y \]
     \[ \phi = 0.9 \]
     \[ f_{un} \] is the factored normal stress
     \[ F_y \] is the yield strength of steel
   * For limit state of yielding under shear stress:
     \[ f_{uv} \leq \phi \cdot (0.6 \cdot F_y) \]
     \[ \phi = 0.9 \]
     \[ f_{uv} \] is the factored shear stress
   * For the limit state of buckling:
     \[ f_{un} \leq \phi \cdot c \cdot F_{cr1} \]
     \[ \phi = 0.85 \]
     \[ f_{un} \] is the factored normal stress
     \[ F_{cr1} \] is the critical buckling stress in compression (AISC section E3)

     or

     \[ f_{uv} \leq \phi \cdot c \cdot F_{cr2} \]
     \[ \phi = 0.85 \]
     \[ f_{uv} \] is the factored shear stress
     \[ F_{cr2} \] is the critical buckling stress in shear = 0.6 \( F_y \) (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:

   \[ \frac{\sigma_a}{0.85 F_y} \leq 1 \left( \frac{1}{1 - 0.51} - \frac{\sigma_b}{0.9 F_y} + \frac{\sigma_w}{0.9 F_y} \right) \leq 1.0 \]

   where:
   \[ \sigma_a \] = Factored Axial Stress
   \[ \sigma_b \] = Factored Strong Axis Bending Stress
   \[ \sigma_w \] = Factored Weak Axis Bending Stress
   \[ c \] = Factored Normal Stress due to Warping
   \[ F_{cr} \] = minimum of \( F_y \) or \( F_{cr, elastic} \) (AISC equation F2-4)

   \[ Pu \] = Factored Axial Force

   \[ Pex \] and \[ Pey \] are the Euler Buckling Loads in the Strong and Weak axes, respectively

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 to the yellow highlighted cells.

     For the beams 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.

```
Checking the LRFD Flexural-Torsional Stresses in a Steel Beam using the STAAD.pro output results:

Created By:
HAZIM F. SHARHAN, Ph.D., P.E.
```
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<th>Fz kip</th>
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Checking the LRFD Flexural-Torsional Stresses in a Steel Beam using the STAAD.pro output results:

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

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<th>End Beam #</th>
<th>Beam Start Joint #</th>
<th>Beam End Joint #</th>
<th>Joint Beam Side</th>
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<th>End</th>
<th>Design Torsion (ft-kip)</th>
<th>x (ft)</th>
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<th>Web Span</th>
<th>Load</th>
<th>R. Support</th>
<th>L. Support</th>
<th>Top Range - Direct Torsional Shear Stress (F-lb)</th>
<th>Top Range - Weakening Shear Stress (F-lb)</th>
<th>Top Range - Weakening Normal Stress (ksi)</th>
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Checking the LRFD Flexural-Torsional Stresses in a Steel Beam using the STAAD.pro output results:

Start here

### Loaded point laterally unrestrained

1

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<th>Piece #</th>
<th>Member Number</th>
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### Results from Torsional Check Sheet

**Check Interaction of Individual Stresses**

- **Check-1:** $\sigma_{u,n} / (0.9F_y)$ = 0.34 Good
- **Check-2:** $\tau_{u,w} / (0.9(0.6F_y))$ = 0.17 Good
- **Check-3:** $\tau_{u,f} / (0.9(0.6F_y))$ = 0.12 Good
- **Check-4:** $\sigma_{u,n} / (0.9F_{cr,1})$ = 0.38 Good
- **Check-5:** $\tau_{u,w} / (0.9F_{cr,2})$ = 0.17 Good

**Check Interaction of combined Stresses:**

$$F_{cr,1} = 44.87 \text{ ksi, } P_{e,y} = 3.37E+03 \text{ kips}$$

- **Check-1:** $\sigma_{u,n} / (0.9F_{cr,1})$ = 0.34 Good
- **Check-2:** $\tau_{u,w} / (0.9(0.6F_{cr,1}))$ = 0.17 Good
- **Check-3:** $\tau_{u,f} / (0.9(0.6F_{cr,1}))$ = 0.12 Good
- **Check-4:** $\sigma_{u,n} / (0.9F_{cr,2})$ = 0.38 Good
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**Amplification:** 1.030