

# Problem #1

## I. Problem

Given a non-standard WF shape shown below with ( $F_y = 36 \text{ ksi}$ ,  $F_u = 58 \text{ ksi}$ ). The bolts are  $\frac{3}{4}$  " in diameter. The connection is bolted at the flange and web as shown. Use LRFD method. Use effective gage distance between the flange hole and web hole,  $g^*$ .

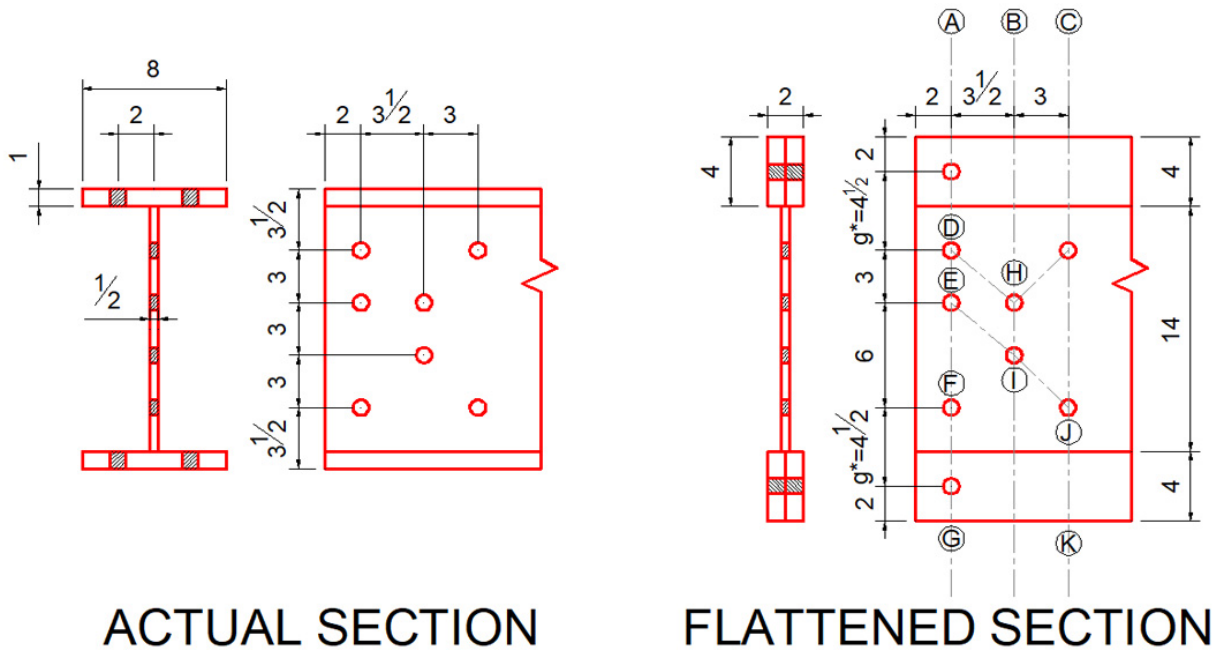


Figure 1.1 Section details

Determine:

1. The value of equivalent gage distance between the web and the adjacent hole  $g^*$ .
2. The tensile capacity  $\phi T_n$  using LRFD method.
3. The allowable tensile load  $\frac{T_n}{\Omega_t}$  using FS of 1.67 for yielding at gross section and 2.0 for fracture at the connection.
4. Is there a possible failure path if the member is connected at the web only?

## II. Solutions

1. First is to determine the hole diameters of the section.

$$diameter = \frac{3}{4} + \frac{1}{8} = \frac{7}{8} \text{ "}$$
(1)

2. To solve for the equivalent gage distance,  $g^*$ , half of the flange was first considered (consider this as a leg). Connecting the end of the leg to the end of the web as shown below:

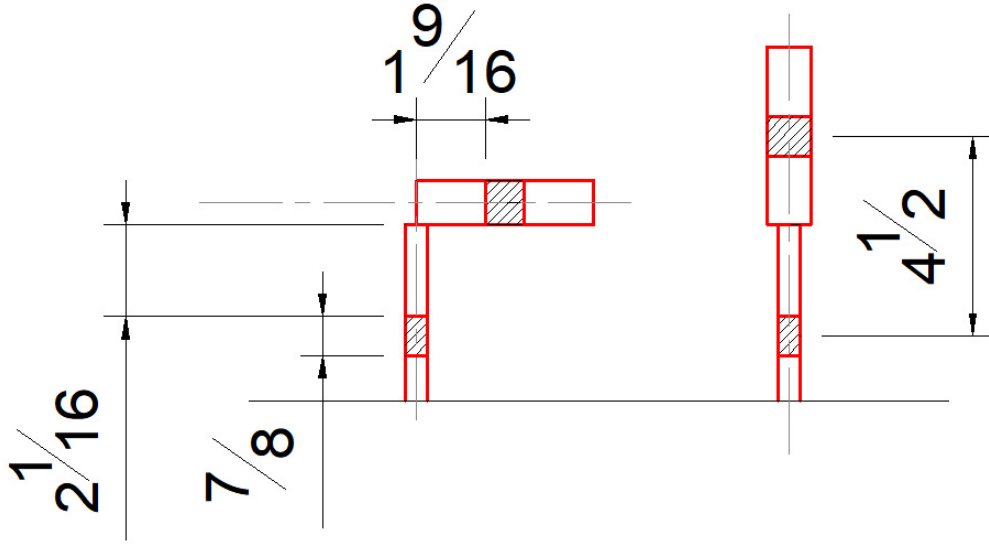


Figure 2.1

$$g^* = 2 \frac{1}{16} + 1 \frac{9}{16} + \frac{7}{16} + \frac{7}{16} \quad (2)$$

$$g^* = 4 \frac{1}{2}''$$

3. From Figure 1.1, (flattened section), gross sectional area is calculated,  $A_g = 23.0 \text{ in}^2$ .

4. Also from figure 1.1, (flattened section), several paths of failures are determined and analyzed, taking into account the non-uniformity of thickness of the section. The following paths are analyzed using python programming:

- A - G
- C - K
- A - E - I - F - G

5. Tensile capacity,  $\phi_t T_n$  using LRFD method:

- Calculating yielding at gross section

$$\phi_t T_n = 0.90 \cdot F_y \cdot A_g, \text{ obtains } \phi_t T_n = 745.20 \text{ kips.}$$

- This analyses of the three (3) paths gives that the path A-G is has the least net area so this path governs and should be analyzed for rupture at connections.

$$A_{net} = A_g - \sum D \cdot t + \sum \frac{s^2}{4g} \cdot t \quad (3)$$

$$A_{net} = 18.19 \text{ in}^2$$

- Calculating the tensile capacity for rupture at connection,

$$\phi_t T_n = 0.75 \cdot F_u \cdot A_{net} \quad (4)$$

obtains  $\phi_t T_n = 791.16$ .

Since yielding at gross section governs, the tensile capacity based on **LRFD** method is

$$\phi_t T_n = 745.20 \text{ kips}$$

6. Allowable tensile load  $\frac{T_n}{\Omega_t}$  using ASD method

- Calculating yielding at gross section

$$\frac{T_n}{\Omega} = \frac{F_y \cdot A_g}{1.67} \quad (5)$$

obtains  $\frac{T_n}{\Omega} = 495.81 \text{ kips}$

- Using the same net area above, tensile rupture at connection,

$$\frac{T_n}{\Omega} = \frac{F_u \cdot A_{net}}{2.0} \quad (6)$$

obtains  $\frac{T_n}{\Omega} = 527.44 \text{ kips}$

Since yielding at gross section governs as well, the allowable tensile load based on **ASD** is

$$T_n/\Omega = 495.81 \text{ kips}$$

7. Possible path failure if member is connected at web only. To find this, first is obtaining the tensile failure at weakest path, removing the holes at the thicker portion of the section then compare it to tensile block shear failure taken at A-C-D-F.

