**Analysis of Vertical Bracing Connections Using Extended Tab Plates**

A procedure was given in Chapter 2 of the Structural Steel Designer's Handbook, 4th Edition to determine the force distribution for a vertical brace connection using extended shear tabs. This procedure was correct. However, it required an inordinate amount of care on the part of the designer to make sure that the free bodies all balanced. Though the original discussion was more transparent as to the way the forces were distributed and the rationale behind the procedure, the procedure shown below is simpler and more complete. This makes it better suited to general use. Also note that there are no provisions in the procedure shown here for $\bar{\alpha}$ or $\bar{\beta}$. This is because the usual relationship between $\alpha$ and $\beta$ inherent in the Uniform Force Method has been eliminated. By manipulating $\Delta Vb$ we are still able to obtain a force distribution identical to that shown in the Handbook.

Gusset-to-Column Connection

$$V_c = P\left[\cos(\theta) - \frac{e_b\left(\sin(\theta)(e_b+\beta) - \cos(\theta)e_c\right)}{\alpha(e_b+\beta)}\right] + R\left(\frac{\beta}{e_b+\beta}\right) + \Delta V_b$$

$$H_c = P\left(\frac{\cos(\theta)e_c}{e_b+\beta}\right) + R\left(\frac{e_c}{e_b+\beta}\right)$$

Gusset-to-Beam Connection

$$V_b = P\left[\frac{e_b\left(\sin(\theta)(e_b+\beta) - \cos(\theta)e_c\right)}{\alpha(e_b+\beta)}\right] + R\left(\frac{e_b}{e_b+\beta} - 1\right) - \Delta V_b$$

$$H_b = P\left(\sin(\theta) - \frac{\cos(\theta)e_c}{e_b+\beta}\right) - R\left(\frac{e_c}{e_b+\beta}\right)$$

$$M_b = \alpha V_b - e_b H_b - Re_c$$

Beam-to-Column Connection

$$H_{bc} = H_c$$

$$V_{bc} = V_b + R$$

For the example shown in Chapter 2 of the Structural Steel Designer's Handbook, 4th Edition. See Figure 1 and 2 below.

**TOP GUSSET FORCES**

Gusset-to-Column Connection

$$V_{c1} = 89\left[\cos(59.74) - \frac{9.00\left(\sin(59.74)(9.00+9.00) - \cos(59.74)10.75\right)}{8.875(9.00+9.00)}\right] + 24.5\left(\frac{9.00}{9.00+9.00}\right) + 28.4$$

$$= 34.7 \text{ kips}$$

$$H_{c1} = 89\left(\frac{\cos(59.74)10.75}{9.00+9.00}\right) + 24.5\left(\frac{10.75}{9.00+9.00}\right) = 41.4 \text{ kips}$$

Gusset-to-Beam Connection

$$V_{b1} = 89\left[\frac{9.00\left(\sin(59.74)\left(9.00+9.00\right)-\cos(59.74)10.75\right)}{8.875\left(9.00+9.00\right)}\right]+24.5\left(\frac{9.00}{9.00+9.00}-1\right)-28.4$$

$$= 10.1 \text{ kips}$$

$$H_{b1} = 89\left(\sin(59.74)-\frac{\cos(59.74)10.75}{9.00+9.00}\right)-24.5\left(\frac{10.75}{9.00+9.00}\right) = 35.4 \text{ kips}$$

$$M_{b1} = (8.875)10.1-(9.00)35.4-(24.5)10.75 = -492 \text{ k}-\text{in}$$

Beam-to-Column Connection

$$H_{bc1} = 41.4 \text{ kips}$$

$$V_{bc1} = 10.1+24.5 = 34.6 \text{ kips}$$

Tab Plate

$$\text{Shear} = H_{bc1} = 41.6 \text{ kips}$$

$$\text{Moment} = V_{c1}e_c - H_{c1}\beta_1 = (34.7)10.75-(41.4)9.00 = 0.425 \text{ k}-\text{in} \approx 0$$

**BOTTOM GUSSET FORCES**

Gusset-to-Column Connection

$$V_{c2} = 140\left[\cos(59.74)-\frac{9.00\left(\sin(59.74)\left(9.00+10.5\right)-\cos(59.74)10.75\right)}{8.875\left(9.00+10.5\right)}\right]+24.5\left(\frac{10.5}{9.00+10.5}\right)+50.7$$

$$= 51.2 \text{ kips}$$

$$H_{c2} = 140\left(\frac{\cos(59.74)10.75}{9.00+10.5}\right)+24.5\left(\frac{10.75}{9.00+10.5}\right) = 52.4 \text{ kips}$$

Gusset-to-Beam Connection

$$V_{b2} = 140\left[\frac{9.00\left(\sin(59.74)\left(9.00+10.5\right)-\cos(59.74)10.75\right)}{8.875\left(9.00+10.5\right)}\right]+24.5\left(\frac{9.00}{9.00+10.5}-1\right)-50.7$$

$$= 19.3 \text{ kips}$$

$$H_{b2} = 140\left(\sin(59.74)-\frac{\cos(59.74)10.75}{9.00+10.5}\right)-24.5\left(\frac{10.75}{9.00+10.5}\right) = 68.5 \text{ kips}$$

$$M_{b2} = (8.875)19.3-(9.00)68.5-(24.5)10.75 = -708 \text{ k}-\text{in}$$

Beam-to-Column Connection

$$H_{bc2} = 52.4 \text{ kips}$$

$$V_{bc2} = 19.3+24.5 = 43..8 \text{ kips}$$

Tab Plate

$$\text{Shear} = H_{bc2} = 52.4 \text{ kips}$$

$$\text{Moment} = V_{c2}e_c - H_{c2}\beta_2 = (51.2)10.75 - (52..4)10.5 = 0.20 \text{ k} - \text{in} \approx 0$$

**BEAM TO COLUMN CONNECTION**

$$V_{bc} = V_{bc1} + V_{bc2} = 34.6 + 43.8 = 78.4 \text{ kips}$$
$$H_{bc} = H_{bc1} - H_{bc2} = 41.4 - 52.4 = -11.0 \text{ kips}$$

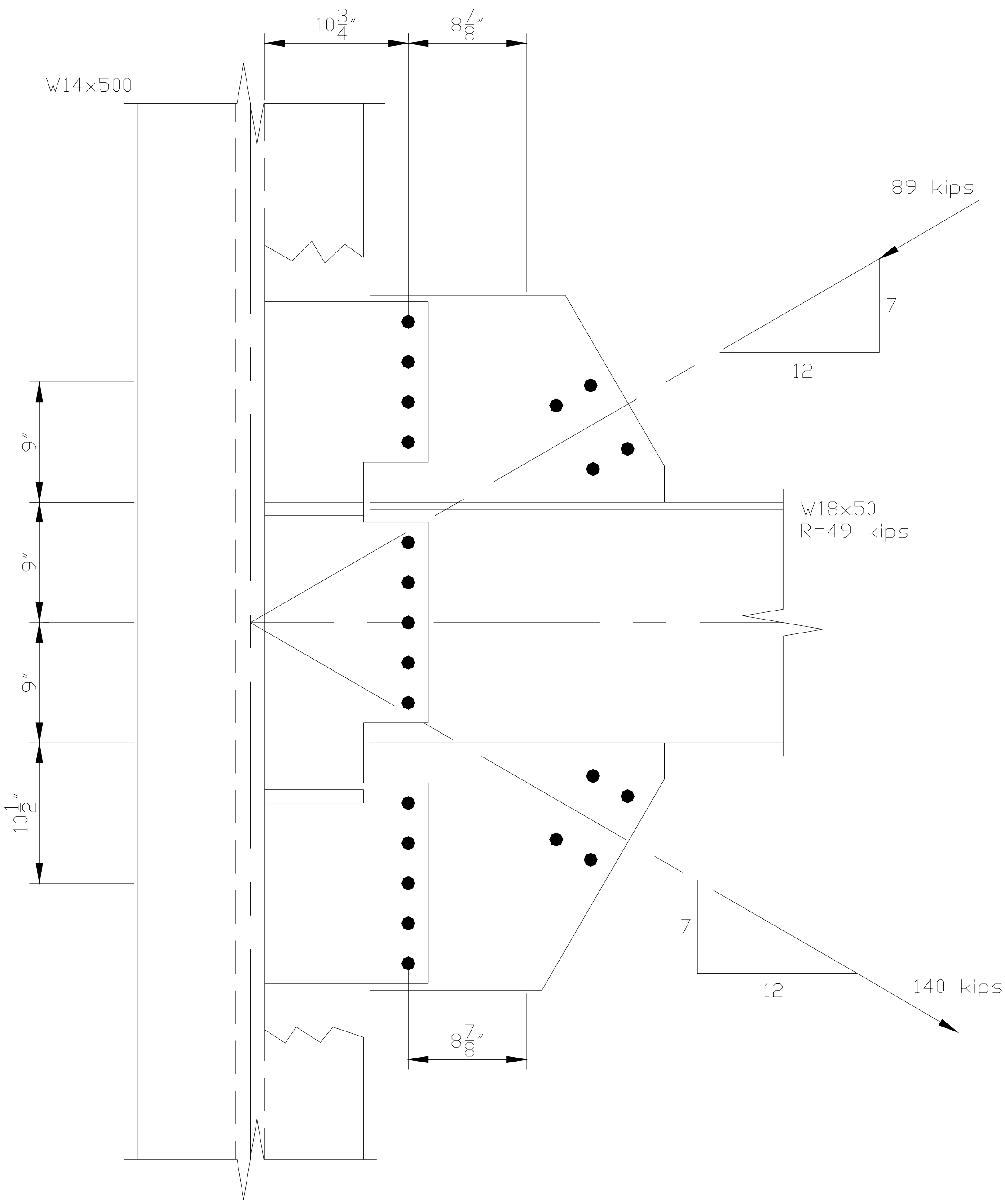


Figure 1 – Vertical Bracing Configuration

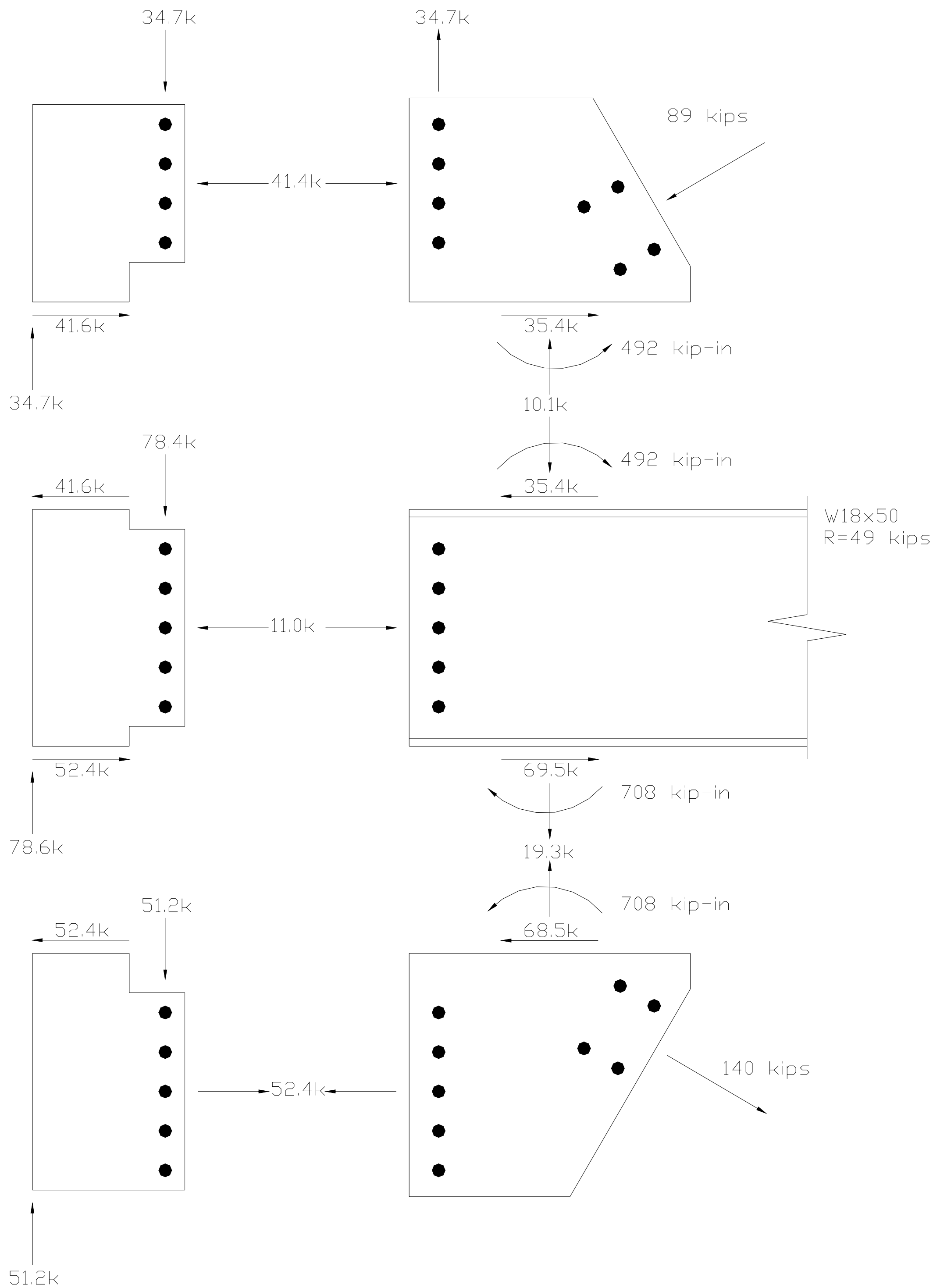


Figure 2 – Free Body Diagram of Exploded Connection