F. Design Procedure for Beam-to-Column Connections

There is no standard set of design steps but the following will give some indication of how most designs proceed:

Step 1: Design Load
Compute the factored shear loads at the ends of the beam. The dead and live loads for the shear are combined with the usual factors of safety.

\[ V_u = \max\{(1.2V_D + 1.6V_L), 1.4V_D\} = \text{Total Shear load at the beam ends} \]

Step 2: Beam Web Connection.
The number and size of the bolts must be large enough to handle shear load. This is determined from the bolt shear and bearing calculations. Note that the beam web connections act in double shear.

- **Bolt Shear and Bearing** (To determine number of bolts, \( n \))
  \[ P_u = \frac{V_u}{n} = \text{Load on each bolt} \]

  The capacity of the connection is controlled by the **bolt shear capacity** and the **bearing capacity**, whichever is smaller.

  \[ P_u \leq \phi R_n = \min\{0.75mF_v^bA_b, 1.8dtF_u\} \]

- **Bolt Spacing**
  Check bolt spacing:

  \[ s \geq 3d \quad 1.5d < L_e \leq 12t \leq 6\text{"} \]

  If the usual (recommended) spacing requirements are satisfied, then no further check is necessary. Otherwise, (if the recommended spacing cannot be satisfied due to lack of space on the beam web), the bolt bearing formulas (J3-1) are not valid so that the formulas (J3) should be checked.

- **Web Shear Capacity**
The depth of the beam is needed in the following calculations. It is obtained from the “Dimensions and Properties” Tables. The hole diameter \( D' = \text{bolt diameter} + 1/16" \) is used:

  \[ V_u \leq \phi_v V_n = 0.54F_v \text{(Depth)}t_w \quad \text{(Shear yield)} \]

  \[ V_u \leq \phi 0.6F_u A_{nv} = 0.75(0.6)F_u((\text{Depth}) - nD')t_w \quad \text{(Shear fracture)} \]

Step 3: Connection Angle.
The AISC manual offers a special table to help find the lightest connection angle. The angle capacity and bolt spacing are checked.
• **Selection:** Use Table 9-2 (AISC 9-22 to 9-87) to find the angle thickness $t$ and length $L$.

• **Shear Yielding and Fracture:**

\[
V_u \leq \phi 0.6 F_y A_{gv} = 0.9(0.6)F_y 2Lt \quad \text{(Shear yield)}
\]
\[
V_u \leq \phi 0.6 F_u A_{nv} = 0.75(0.6)F_u (2)(L - nD)t \quad \text{(Shear fracture)}
\]

• **Bolt Bearing:** If the total thickness of the two angles is greater than the thickness of the web ($2t \geq t_w$), then the angles will be strong enough and the angles will be no longer checked. Otherwise, bearing must be checked using (J3-1) for recommended spacing and (J3-2) for other spacings.

• **Edge Distance:** Check minimum and maximum spacing.

**Step 4:** **Column.**

Check if the column flange is thicker than the angle or half of the beam web. If it is (which is the usual case), then bearing and shear failure will occur in the beam web or the angle before it occurs in the column. Therefore, it would not be necessary to check this part of the connection.