## D. Design Procedure for Bolted Angles under Tension Loads

In designing a bolted angle under tension loads, there are three design aspects we may consider:

1. How many and what size bolts are necessary?
2. What is the optimal (lightest) size of the angle?
3. Where and how close should the bolts be placed?

The item 2 was already covered previously in Chapter 2 of the lecture notes (in tension members). The design strength formulas are now used to develop a method to deal with items 1 and 3. A suggested design procedure is the following:

**Step 1: Design Load.**
Determine factored load:

$$\text{Total Load} = P_u = \max\{1.2P_D + 1.6P_L, 1.4P_D\}$$

**Step 2: Number of bolts and thickness of angle.**
There should be enough number of bolts used to handle **shear load**. Furthermore, the angle must be thick enough to carry the **bearing stress**. For both case the formula to be used is:

$$\frac{\text{Total load on angle}}{\text{Number of bolts}} = (\text{Load on each bolt}) \leq (\text{Strength of each bolt})$$

The bolt strength depends on the **bolt shear** and **bearing capacity** of the hole in the angle.

- **Bolt shear** (Determine number of bolts $n$).

$$T_u = P_u/n = \text{Load on each bolt}$$

$$\phi R_n = m\phi F_v^b A_b$$

- **Bearing capacity** (Determine thickness of the angle $t$).

$$\phi R_n = \cdots \quad \text{Use (J3-1) and (J3-2).}$$

$$T_u \leq \phi R_n \quad \text{Design criterion.}$$

**Step 3:** **Angle Selection.** (Refer to Chapter 3)
The strength of the angle depends on **yielding in the gross area** and **fracture in the net area**.

Yield in the gross area:

$$P_u \leq 0.9 F_y A_g$$

Fracture in net area:

$$P_u \leq 0.75 F_u U A_n$$

**Step 4:** **Bolt Spacing.**

The bolt spacing ($s$) and edge distance ($L_e$) should be large enough to handle the bearing stresses. See formulas and tables given in this section of lecture notes.

**Step 5:** **Check Block Shear Rupture.**

Shear yield + Tension fracture:

$$P_u = \phi P_n = \phi(0.6 F_y A_{gv} + F_u A_{nt}) \quad \text{(J4-3a)}$$

Shear fracture + Tension yield:

$$P_u = \phi P_n = \phi(0.6 F_u A_{nv} + F_y A_{gt}) \quad \text{(J4-3b)}$$

where $\phi = 0.75$.