Chapter 7.
Flexural Analysis of Non-Rectangular Beams

7.1. Balanced Steel for Beams with Non-Rectangular Sections

In this section we establish a general procedure for the computation of the balanced steel area $A_{sb}$ for a cross section of any shape that is symmetrical with respect to a vertical axis or that is constrained so that under load it deflects vertically without twisting. The resultant $C_c$ is not located at $a/2$ because the stress block is not a rectangle, passes through the centroid of the stress block area $A_c$. The step-by-step procedure for computing $A_{sb}$ is detailed below.
7.2. Example. Analysis of Non-Rectangular Sections

Find the balanced area, $A_{sb}$ for the following section:

Given

\[ f'_c = 5,000 \text{ psi} \]
\[ f_y = 60,000 \text{ psi} \]

Solution

Select $c/d$ to be right at the borderline of Transition and Tension Controlled”:

\[ \frac{c}{d} = 0.375 \rightarrow 0.375 \times 30 = 11.25 \text{ inches} \]
\[ a = \beta_1 c = 0.80 \times 11.28 = 9 \text{ inches} \]

\[ C_c = 0.85f'_c \times (shaded \ area) \]
\[ = 0.85 \times (5 \ ksi) \times \left[ 16 \times 13 \times \frac{1}{2} + (9 \times 8) \times 16 \right] = 340 \text{ kips} \]

From Equilibrium:

\[ \sum T = \sum C \rightarrow A_y f_y = C_c \rightarrow A_{sb} = \frac{C_c}{f_y} = \frac{340 \text{ kips}}{60 \text{ kips/in}^2} = 5.67 \text{ in}^2 \]
7.3. Example. Nominal Moment Capacity of Non-Rectangular Sections

Calculate nominal moment capacity of the beam given below.

![Diagram of beam with dimensions and symbols]

**Given**

\[
f'_c = 5,000 \text{ psi} \\
fy = 60,000 \text{ psi} \\
A_s = 4.0 \text{ in}^2
\]

**Tension Failure**

**Solution**

Assume “a” such that a<13"

\[
A = \frac{1}{2} a(2\gamma)
\]

From geometry: \( \gamma = a \times \frac{8}{13} \)

Uniform compression over the area: \( 0.85f'_c = 4.25 \text{ ksi} \)

For equilibrium we have:

\[
\sum T = \sum C \rightarrow Afy = Cc \rightarrow 240 \text{ kips} = a^2 \times 4.25
\]

Solving for \( a \) we get:

\( a=7.5 \) in < 8 in; Therefore our **assumption is correct**

Determine the moment capacity of the cross section:

\[
M_n = A_s fy (30 - \frac{2}{3}(7.5)) = 6,000 \text{ in} - \text{kips}
\]

Notice that a factor of 2/3 is used to locate the neutral axis of a triangular cross-section. (refer to your statics book to refresh yourselves).