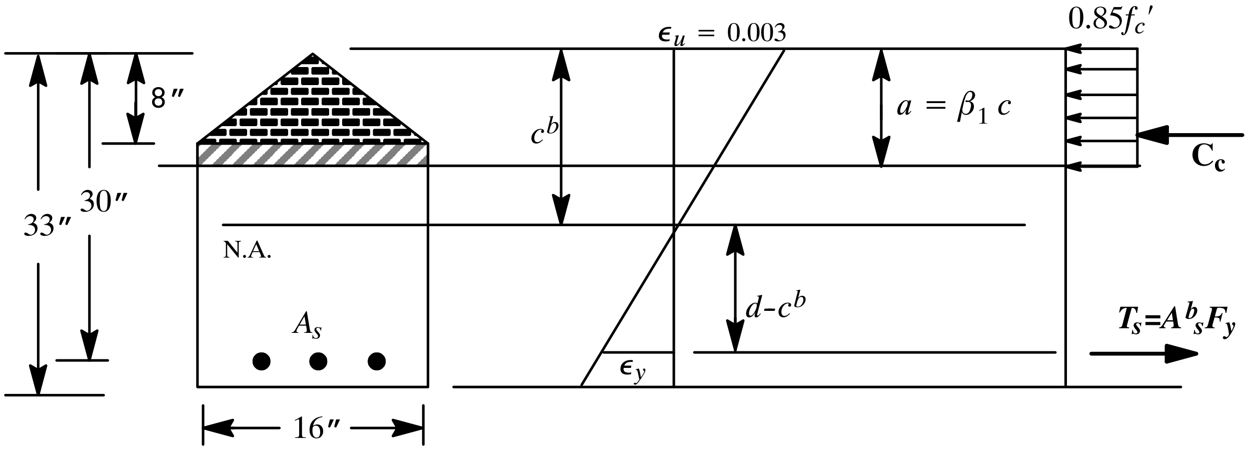
Chapter 7.
Flexural Analysis of Non-Rectangular Beams

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

$$f_c' = 5,000 \ psi$$

$$f_y = 60,000 \ psi$$

Solution

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

$$\frac{c}{d} = 0.375 \rightarrow 0.375 \times 30 = 11.25 \ inches$$

$$a = \beta_1 c = 0.80 \times 11.28 = 9 \ inches$$

$$C_c = 0.85 f_c' \times (shahed \ \ area)$$

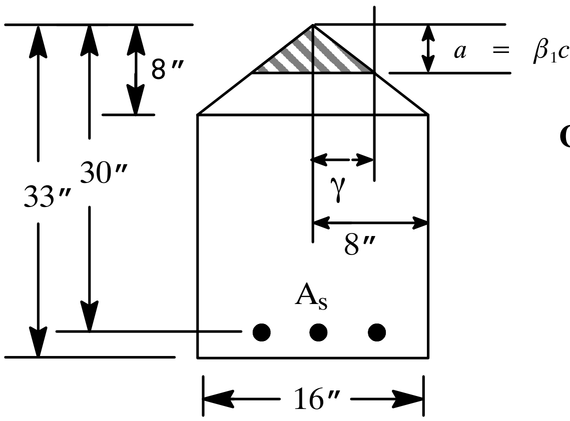
$$= 0.85 \times (5 \ ksi) \times \left[\underbrace{16 \times 13 \times \frac{1}{2}}_{\text{Area of dashed triangle}} + \underbrace{(9 - 8) \times 16}_{\text{Area of dashed rectangle}} \right] = 340 \ kips$$

From Equilibrium:

$$\sum T = \sum C \rightarrow A_s^b f_y = C_c \rightarrow A_{sb} = \frac{c_c}{f_y} = \frac{340 \ kips}{60 \ kips/in^2} = 5.67 \ in^2$$

7.3. Example. Nominal Moment Capacity of Non-Rectangular Sections

Calculate nominal moment capacity of the beam given below.



Given

$$f_c' = 5,000\ psi$$

$$f_y = 60,000\ psi$$

$A_s = 4.0\ \text{in}^2$

Tension Failure

Solution

Assume "a" such that a<13″

$$\left.\begin{aligned} A &= \frac{1}{2}a(2\gamma) \\ From\ geometry:\ \gamma &= a \times \frac{8}{13} \end{aligned}\right\} \quad A = a^2\left(\frac{8}{8}\right)$$

Uniform compression over the area: $0.85f'_c = 4.25$ ksi
For equilibrium we have:

$$\sum T = \sum C \rightarrow A_s f_y = C_c \rightarrow 240\ kips = a^2 \times 4.25$$

Solving for a we get:

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

Determine the moment capacity of the cross section:

$$M_n = A_s f_y\left(30 - \frac{2}{3}(7.5)\right) = 6,000\ in - kips$$

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).