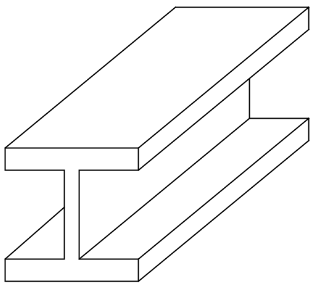
CEE421

Concrete Beam Design

Beam Design



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1 Beam Design

1.1 Deriving the Design Equations

Equation 1 is the basic design relationship for concrete beams.

$$\phi M_n \geq M_u \tag{1}$$

The nominal moment of the beam is found by taking moments about the resultant compressive force. The only force left is the tension force in the steel.

$$\phi T_s z \geq M_u \tag{2}$$

Next, plug in the force in the tension steel and the distance from the compressive force to the tensile force.

$$\phi \left(A_s f_y\right) \left(d - \frac{1}{2} a\right) \geq M_u \tag{3}$$

Next, plug in the value for a.

$$\phi \left(A_s f_y\right) \left(d - \frac{1}{2} \frac{A_s f_y}{0.85 f_c' b}\right) \geq M_u \tag{4}$$

We want to get the equation in terms of the *reinforcement ratio*, ρ. We can accomplish this by dividing both sides of the equation by bd^2.

$$\phi \left(\frac{A_s}{bd} f_y\right) \left(\frac{d}{d} - \frac{1}{2} \frac{A_s f_y}{0.85 f_c' bd}\right) \geq \frac{M_u}{bd^2} \tag{5}$$

Substitute the reinforcement ratio into the equation

$$\phi \left(\rho f_y\right) \left(1 - \frac{1}{2} \frac{\rho f_y}{0.85 f_c'}\right) \geq M_u \tag{6}$$

To calculate the reinforcement ratio at the balance condition:

$$\rho_{bal} = \frac{0.85 f_c' \beta_1}{f_y} \left[\frac{87}{f_y + 85}\right] \tag{7}$$

$$\rho_{design} = \frac{0.75 \rho_{bal}}{2} \tag{8}$$

$$\phi \rho f_y \left[1 - \frac{f_y}{1.7 f_c'} \rho\right] \geq \frac{M_u}{bd^2} \tag{9}$$

$$\phi R \geq \frac{M_u}{bd^2} \tag{10}$$

where

$$R(f_c', f_y, \rho) = \rho f_y \left(1 - \frac{f_y}{1.7 f_c' \rho}\right) \tag{11}$$

References