$$\bar{y} = \frac{\sum A_i \bar{y}_i}{\sum A} = \frac{b \times h \times (h/2) + (n-1)A_s \times d}{b \times h + (n-1)A_s} \qquad n = E_S/E_C \qquad f_{t,max} = \frac{M(h-\bar{y})}{I_{tr}} \le f_r$$

$$I_{tr} = \sum (I_0 + AD^2) = \frac{1}{12} bh^3 + bh\left(\frac{h}{2} - \bar{y}\right)^2 + (n-1)A_s(d-\bar{y})^2 \qquad f_s = n\frac{M(d-\bar{y})}{I_{tr}}$$

$$f_{c,max} = \frac{M\bar{y}}{I_{tr}} \qquad M_{cr} = \frac{f_r I_{tr}}{h-\bar{y}} \qquad \bar{y}^2 + \frac{2nA}{b}\bar{y} - \frac{2nA_s d}{b} = 0$$

$$k = -n\rho + \sqrt{n^2\rho^2 + 2n\rho} \qquad I_{tr} = \frac{1}{3} b\bar{y}^3 + nA_s(d-\bar{y})^2$$

$$\rho_b = \alpha_1 \beta_1 \frac{\phi_c}{\phi_s} \frac{f_c}{f_y} \frac{700}{700 + f_y}$$

$$M_r = A_s \phi_s f_y \left(d - \frac{A_s \phi_s f_y}{2\alpha_1 \phi_c f_c b}\right) \qquad \rho_{\min} = \frac{\sqrt{f_c'}}{4 f_y} \ge \frac{1.4}{f_y}$$

$$M_r = \rho \phi_s f_y b d^2 \left(1 - 0.5 \frac{\rho \phi_s f_y}{a_1 \phi_c f_c}\right) \qquad R_r = \frac{M_r}{bd^2} = \frac{M_u}{bd^2} \qquad m_\phi = \frac{\phi_s f_y}{\alpha_1 \phi_c f_c}$$

$$\rho = \frac{1}{m_\phi}\left\{1 - \sqrt{1 - \frac{2 m_\phi R_r}{\phi_s f_y}}\right\} \qquad bd^2 = \frac{M_r}{\rho \phi_s f_y \left(1 - 0.5 \frac{\rho \phi_s f_y}{a_1 \phi_c f_c}\right)}$$

$$\bar{\rho}_b = \rho_b + \rho' \frac{f'_{sb}}{f_y} \qquad f'_{sb} = 700 - \frac{d'}{d}(700 + f_y) \le f'_y$$

$$\bar{\rho}_{\min} = \rho' \frac{f'_y}{f_s} + \alpha_1 \beta_1 \frac{\phi_c}{\phi_s} \frac{f_c}{f_s} \frac{d'}{d} \frac{700}{700 - f'_y} \qquad f_s = \frac{d}{d'}(700 - f'_y) - 700 \le f_y$$

$$M_r = \varphi_s (A_s f_s - A'_s f'_s)\left[d - \frac{\varphi_s (A_s f_s - A'_s f'_s)}{2\alpha_1 \varphi_c f_c b}\right] + \varphi_s A'_S f'_S (d - d')$$

$$a = \frac{\phi_s (A_s f_s - A'_s f'_s)}{\alpha_1 \phi_c f_c b} \qquad f'_s = 700 \frac{a - \beta_1 d'}{a} \qquad f_s = 700 \frac{\beta_1 d - a}{a}$$

$$M_r = \varphi_s (A_s f_s - A'_s f'_s)\left[d - \frac{\varphi_s (A_s f_s - A'_s f'_s)}{2\alpha_1 \varphi_c f_c b}\right] + \varphi_s A'_S f'_S (d - d')$$

$\rho < \overline{\rho_b}$ $\rho > \overline{\rho_{min}}$	$a = \frac{\phi_s (A_s f_y - A'_s f' y)}{\alpha_1 \phi_c f_c b}$
$\rho < \overline{\rho_{min}}$ $\rho < \overline{\rho_b}$	$a^2 + \frac{\phi_s}{\phi_c}\frac{700 A'_s - A_s f_y}{\alpha_1 f_c b} a - \frac{\phi_s}{\phi_c}\frac{700 A'_s \beta_1 d'}{\alpha_1 f_c b} = 0$
$\rho > \overline{\rho_{min}}$ $\rho > \overline{\rho_b}$	$a^2 + \frac{\phi_s}{\phi_c}\frac{A'_s f'_y - 700 A_s}{\alpha_1 f_c b} a - \frac{\phi_s}{\phi_c}\frac{700 A_S \beta_1 d}{\alpha_1 f_c b} = 0$
$\rho < \overline{\rho_{min}}$ $\rho > \overline{\rho_b}$	$a^2 + \frac{\phi_s}{\phi_c}\frac{700 (A_s + A'_s)}{\alpha_1 f_c b} a - \frac{\phi_s}{\phi_c}\frac{700 \beta_1 (A_s d - A'_s d')}{\alpha_1 f_c b} = 0$

$$M_{rb} = \rho_b \phi_s f_y b d^2 (1 - 0.5 \frac{\rho_b \phi_s f_y}{a_1 \phi_c f_c}) \qquad \Delta M = M_u - M_{rb}$$

$$\Delta M = \varphi_s \Delta A_s f_y (d - d') \qquad \Delta M = \varphi_s A'_S f'_S (d - d')$$

$$b \le 4 b_w \qquad h_f \ge \frac{1}{2} b_w \qquad b_e = \min\left\{\frac{l_n}{4}, b_w + 16 h_f, \frac{l_1 + l_2}{2}\right\}$$

$$a_r = \frac{\varphi_s A_s f_y}{\alpha_1 \varphi_c f_c b} \qquad A_{sf} = \alpha_1 \frac{\varphi_c}{\varphi_s} \frac{f_c}{f_y} h_f (b - b_w) \qquad A_{sb,T} = A_{sf} + \alpha_1 \beta_1 \frac{\varphi_c}{\varphi_s} \frac{f_c}{f_y} \frac{700}{700 + f_y} b_w d$$

$$M_{rf} = \alpha_1 \varphi_c f_c h_f (b - b_w) \left(d - \frac{h_f}{2}\right) = \varphi_s A_{sf} f_y \left(d - \frac{h_f}{2}\right)$$

$$a = \frac{\varphi_s (A_s - A_{sf}) f_y}{\alpha_1 \varphi_c f_c b_w} \qquad M_{rw} = \alpha_1 \varphi_c f_c a b_w \left(d - \frac{a}{2}\right)$$

$$M_{rw} = \varphi_s (A_s - A_{sf}) f_y \left[d - \frac{\varphi_s (A_s - A_{sf}) f_y}{2 \alpha_1 \varphi_c f_c b_w}\right] \qquad M_r = M_{rf} + M_{rw}$$

$$e = 3f \qquad g = \frac{2}{3f} \frac{\varphi_s A_s f_y}{\alpha_1 \varphi_c f_c} \qquad M_r = \varphi_s A_s f_y \left(d - \frac{g}{3}\right)$$

$$V_c = \left(0.95\, v_c + 12 \rho_w \frac{V_u d}{M_u}\right) b_w d \le 1.75 v_c b_w d \qquad V_c = v_c b_w d \quad v_c = 0.2 \varphi_c \sqrt{f_c}$$

$$V_c = \left(0.95\, v_c + 12 \rho_w \frac{V_u d}{M_m}\right) b_w d \le 1.75 v_c b_w d \qquad M_m = M_u - N_u \left(\frac{4h - d}{8}\right)$$

$$V_c = 1.75 v_c b_w d \sqrt{1 + \frac{N_u}{3 A_g}} \qquad V_c = v_c \left(1 + \frac{N_u}{12 A_g}\right) b_w d \qquad V_c = v_c \left(1 + \frac{N_u}{3 A_g}\right) b_w d \ge 0$$

$$V_s = \frac{\varphi_s A_{sv} f_{yv} d}{s} \qquad V_r = V_c + V_s \ge V_u \qquad V_r < 0.25 \varphi_c f_c b_w d$$

$$\left(\frac{A_{vs}}{s}\right)_{req} = \frac{V_u - V_c}{\varphi_s f_{yv} d} \qquad V_u \le 0.125 \varphi_c f_c b_w d \quad \rightarrow S_{max} = \frac{d}{2}$$

$$V_u > 0.125 \varphi_c f_c b_w d \quad \rightarrow S_{max} = \frac{d}{4} \qquad \left(\frac{A_{sv}}{s}\right)_{min} = 0.06 \sqrt{f_c} \frac{b_w}{f_{yv}}$$