Useful Equations:

$$W_u = 1.4W_d + 1.7W_l$$

$$C = T \Rightarrow 0.85 f_c^{'} ab = A_s f_y$$

$$\Rightarrow a = \frac{A_s f_y}{0.85 f_c^{'} b} = \frac{\rho f_y d}{0.85 f_c^{'}} \text{ where } \rho = \frac{A_s}{bd};$$

$$a = c\beta_1 \Rightarrow c = \frac{a}{\beta_1} = \frac{\rho f_y d}{0.85\beta_1 f_c^{'}}$$

$$M_n = A_s f_y (d - \frac{a}{2})$$

$$\varepsilon_t = \frac{d-c}{c}(0.003) \quad , \quad \frac{0.003}{0.003 + \varepsilon_t} = \frac{c}{d}$$

$$c_b = \frac{600}{600 + f_y} d \ ,$$

$$\rho_b = \frac{0.85 f_c' \beta_1}{f_y} (\frac{600}{600 + f_y}),$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mR_u}{f_y}} \right),$$

$$m = \frac{f_y}{0.85 f_c^{'}}$$

$$R_u = \frac{M_u / \phi}{bd^2}$$

$$\rho_{\min} = \max\left\{ \frac{\sqrt{f_c^{'}}}{4 f_y}, \frac{1.4}{f_y} \right\},$$

$$\rho_{\max} = \left(\frac{0.85\beta_1 f_c^{'}}{f_y} \right)\left(\frac{3}{8} \right)$$

$$f = \frac{MC}{I} = \text{M/S}$$

$$M_{cr} = \frac{f_r Ig}{h/2} = f_r \text{xS}$$

$S=bh^2/6$

$$f_r = 0.7\sqrt{f_c^{'}}$$

$$f_c = \frac{P}{A}$$

Ec (Mpa) = 4700 $\sqrt{\quad f_c^{'} \quad (MPa)}$

$$\phi V_n \geq V_u$$

$$V_n = V_c + V_s$$

$$V_u = \phi V_c + \phi V_s \Rightarrow V_s = \frac{V_u - \phi V_c}{\phi}$$

If : $\frac{V_u}{\phi} > 0.5V_c$ Stirrups are required,

$$V_c = \frac{\sqrt{f_c'}}{6} b_w d$$

$$V_s = \frac{A_v f_y d}{s} \quad \textit{shall to be} < \frac{2}{3}\sqrt{f_c'} b_w d = 4V_c$$

Same as

If : $\frac{V_u}{\phi} > 5V_c$ Section is insufficient for shear and to be revised

$$A_{v,\min} = \max\{ \frac{b_w s}{3 f_y} , \frac{\sqrt{f_c'} b_w s}{16 f_y} \}$$

Maximum stirrup spacing:

i. based on beam depth:

$$s_{\max} = \begin{cases} \min\{ d/2, 600\,mm\} & \text{if } V_s \le \frac{\sqrt{f_c'}}{3} b_w d \\ \min\{ d/4, 300\,mm\} & \text{if } V_s > \frac{\sqrt{f_c'}}{3} b_w d \end{cases}$$

ii. based on min A_v :

$$s_{\max} = \min\{ \frac{16 A_v f_y}{\sqrt{f'_c} b_w}, \frac{3 A_v f_y}{b_w} \}$$

$$P_0 = 0.85 f_c' (A_g - A_{st}) + f_y A_{st}$$

$$\phi P_{n(\max)} = \begin{cases} 0.65 \times 0.80 P_0 = 0.52 [0.85 f_c' (A_g - A_{st}) + f_y A_{st}] : \textbf{Tied column} \\ 0.70 \times 0.85 P_0 = 0.595 [0.85 f_c' (A_g - A_{st}) + f_y A_{st}] : \textbf{Spiral column} \end{cases}$$

Spacing of column ties:
16 d_b
48d_t
Least dimension of the column

Specific Gravity-Coarse Aggregate

Bulk Specific Gravity (BSG) , Apparent Specific Gravity (ASG), Absorption (AC)

$$BSG(OD) = \frac{A}{B-C} \qquad BSG(SSD) = \frac{B}{B-C}$$

$$ASG(OD) = \frac{A}{A-C} \qquad \text{Absorption (AC)} = \frac{B-A}{A}\%$$

Dry in Oven: Weight = A **Immerse in Water: Weight = C**

B. Dry with A Cloth: Weight = B (SSD)