Shear - Concrete

$\phi V_n \geq V_u$

$\phi = 0.75$

$V_n = V_c + V_s$

$V_c = 2\sqrt{f'_c}\, b_w d$

$V_s = A_v f_y d / s$

$s = A_v f_y d / V_s$

$$S_{max} = \left[\frac{A_v f_y}{0.75\sqrt{f'_c}\, b_w},\ \frac{A_v f_y}{50 b_w},\ \frac{d}{2} \text{ or } \frac{d}{4} \right]_{min}$$

Grade	(ksi) F_y	(ksi) F_u
36	36	58
50	50	65

Concrete Columns

$P_n = \left[(0.85 f'_c)(A_g - A_{st}) + A_{st} f_y \right]$

$P_u \leq \alpha \phi P_n$

$\phi_{tied} = 0.65 \qquad \alpha_{tied} = 0.80$

$\phi_{spiral} = 0.70 \qquad \alpha_{spiral} = 0.85$

Load Combinations

$U = 1.2DL + 1.6LL$

Tension

$P_u \leq \phi_t F_y A_g \qquad \phi_t = 0.90$

$P_u \leq \phi_t F_u A_e \qquad \phi_t = 0.75$

$P_u \leq \phi P_n \qquad A_e = U A_n$

$r \geq L/300$ slenderness

$S^2/4g$ - stagger

Steel Columns

$P_u \leq \phi_c A_g F_{cr} \qquad \phi_c = 0.85$

$P_u \leq \phi P_n$

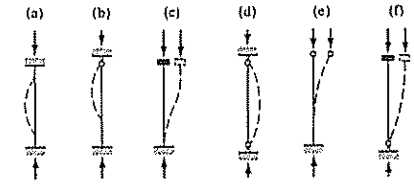
$\lambda_c = \frac{kL}{r\pi}\sqrt{F_y/E} \qquad E = 29{,}000 \text{ ksi}$

$F_{cr} = (0.658^{\lambda_c^2}) F_y$ for $\lambda \leq 1.5$ inelastic buckling

$F_{cr} = \left(\frac{0.877}{\lambda_c^2}\right) F_y$ for $\lambda \geq 1.5$ elastic buckling

$(K_y L_y)_{equiv} = \frac{K_x L_x}{(r_x/r_y)}$

TABLE 5.1 Column Effective Lengths

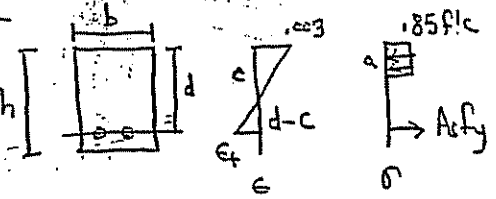


	(a)	(b)	(c)	(d)	(e)	(f)
Buckled shape of column is shown by dashed line						
Theoretical K value	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design value when ideal conditions are approximated	0.65	0.80	1.2	1.0	2.10	2.0

Flexure – Concrete

$T = A_s F_y$

$C = 0.85 f'_c b a$



$\phi M_n \geq M_u$

$M_n = A_s F_y (d - a/2)$

$\frac{\epsilon_t}{d-c} = \frac{.003}{c}$

ϕ_b (Fig 3.5)

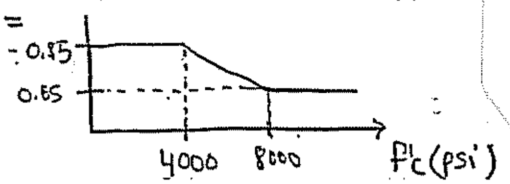
$\rho = A_s / bd \qquad a = \beta_1 c$

$A_{s_{min}} = \left[\frac{3\sqrt{f'_c}}{f_y} b_w d \text{ or } \frac{200 b_w d}{f_y} \right]_{min}$

$\frac{M_u}{\phi b d^2} = \rho f_y \left[1 - \frac{1}{1.7} \frac{\rho f_y}{f'_c} \right]$

$\rho_b = \frac{.85 f'_c \beta_1}{f_y} \left[\frac{87{,}000}{87{,}000 + f_y} \right]$

$\beta_1 =$



Cracking Moment

$M_{cr} = f_r I_g / y_t$

$f_r = 7.5\sqrt{f'_c}$

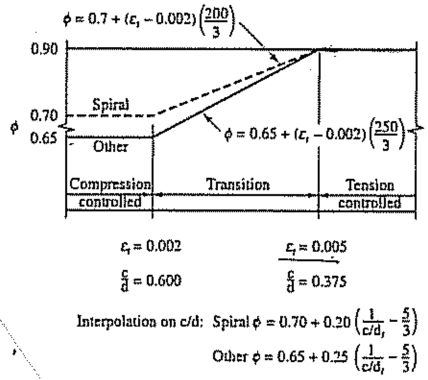
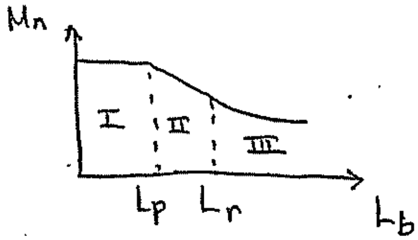


Figure 3.5 Variation of ϕ with net tensile ϵ_t and c/d for Grade 60 reinforcement and for prestressing steel. (Printed with permission of American Concrete Institute.)

Flexure – Steel



Zone I

$\phi M_n = \phi_b F_y Z$

$Z_{req} = \frac{M_u}{\phi_b F_y}$

$\phi M_n \geq M_u$ (all zones)

Zone II

$\phi M_n = \phi C_b \left[M_p - (M_p - M_r)\left(\frac{L_b - L_p}{L_r - L_p}\right) \right] \leq M_p$

Zone III

$\phi M_{cr} = \frac{\phi C_b S_x X_1 \sqrt{2}}{L_b / r_y} \sqrt{1 + \frac{X_1^2 X_2}{2(L_b/r_y)^2}}$