Ultimate Strength Design Method

(Singly Reinforced Beams)

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Ultimate Strength Design Philosophy

design strength $\geq$ required strength

$$\phi S_n \geq U$$

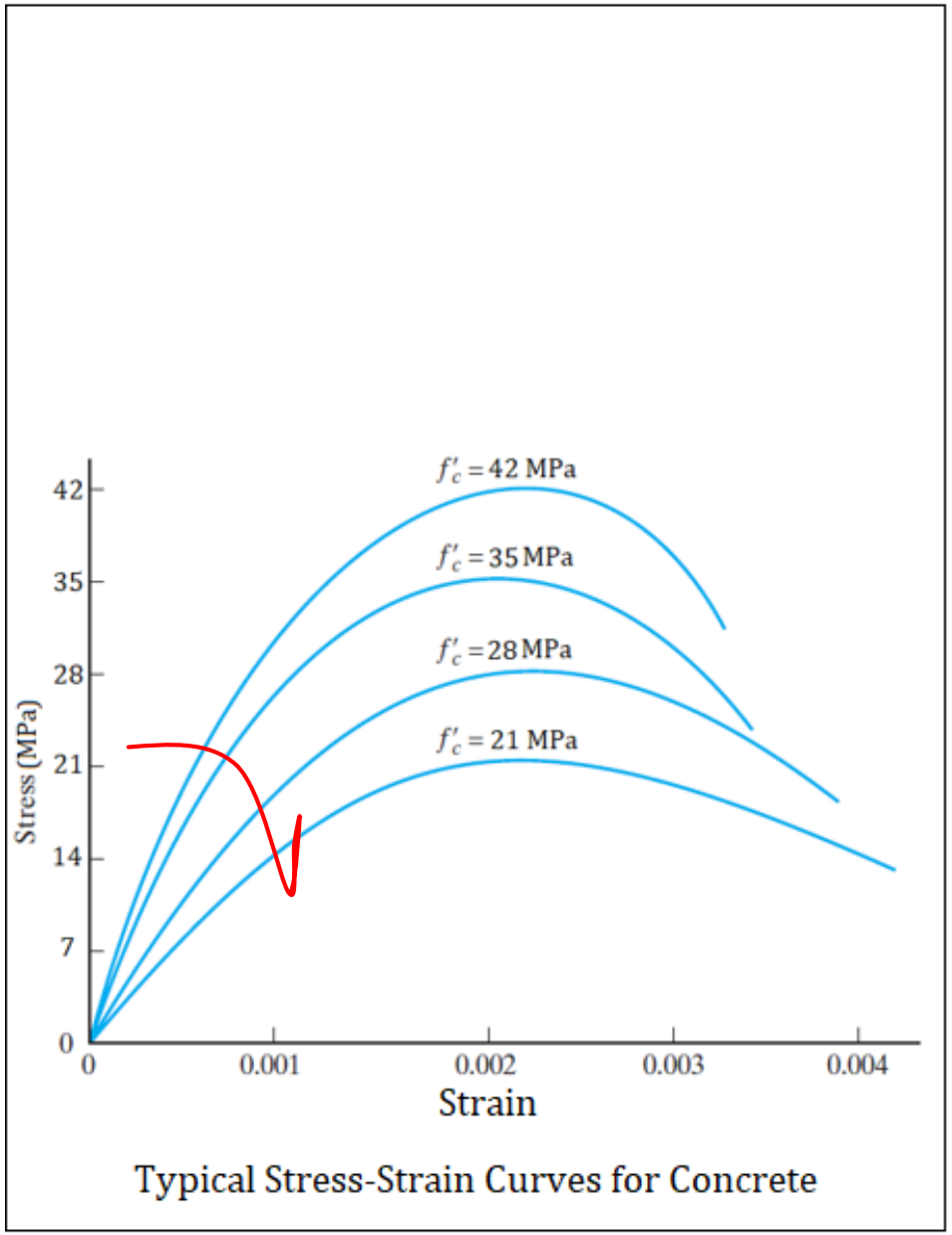
$$\emptyset M_n \geq M_u$$
$$\emptyset V_n \geq V_u$$
$$\emptyset T_n \geq T_u$$
$$\emptyset P_n \geq P_u$$

Table: 21.2.1 Strength Reduction Factor Ø

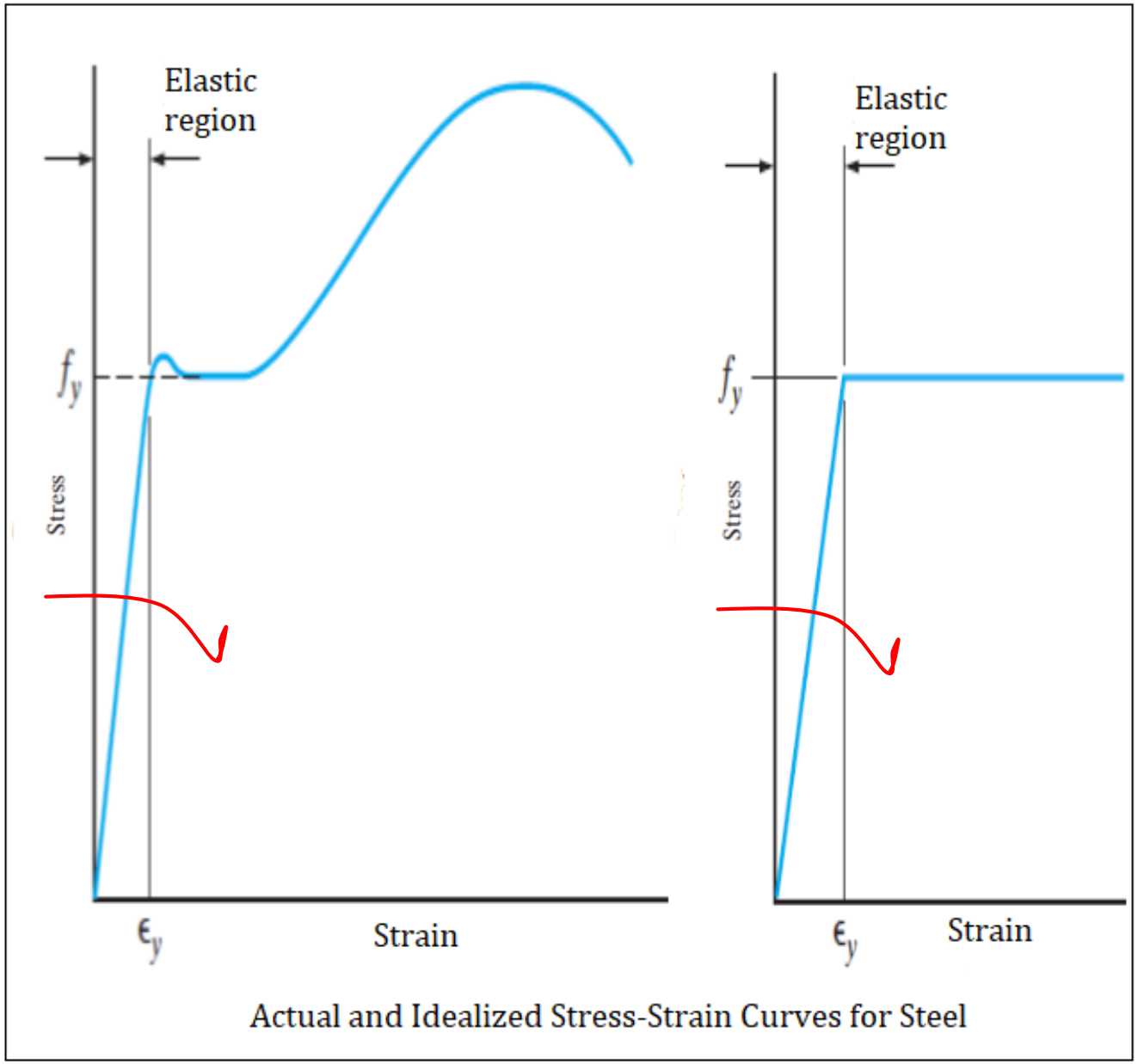
Action or Structural Element	Ø
Moment (Tension Controlled)	0.90
Shear	0.75
Torsion	0.75
Bearing	0.65
Plain Concrete Elements	0.60

Table 5.3.1—Load combinations

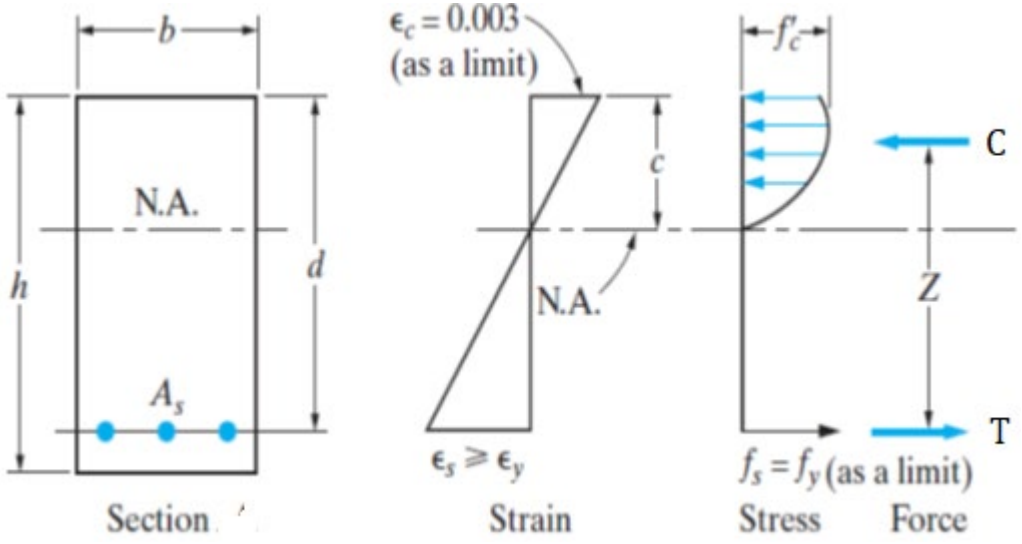
Load combination	Equation	Primary load
$U = 1.4D$	(5.3.1a)	D
$U = 1.2D + 1.6L$		L
$U = 1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$	(5.3.1b)	L
$U = 1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (1.0L \text{ or } 0.5W)$	(5.3.1c)	L_r or S or R
$U = 1.2D + 1.0W + 1.0L + 0.5(L_r \text{ or } S \text{ or } R)$	(5.3.1d)	W
$U = 1.2D + 1.0E + 1.0L + 0.2S$	(5.3.1e)	E
$U = 0.9D + 1.0W$	(5.3.1f)	W
$U = 0.9D + 1.0E$	(5.3.1g)	E

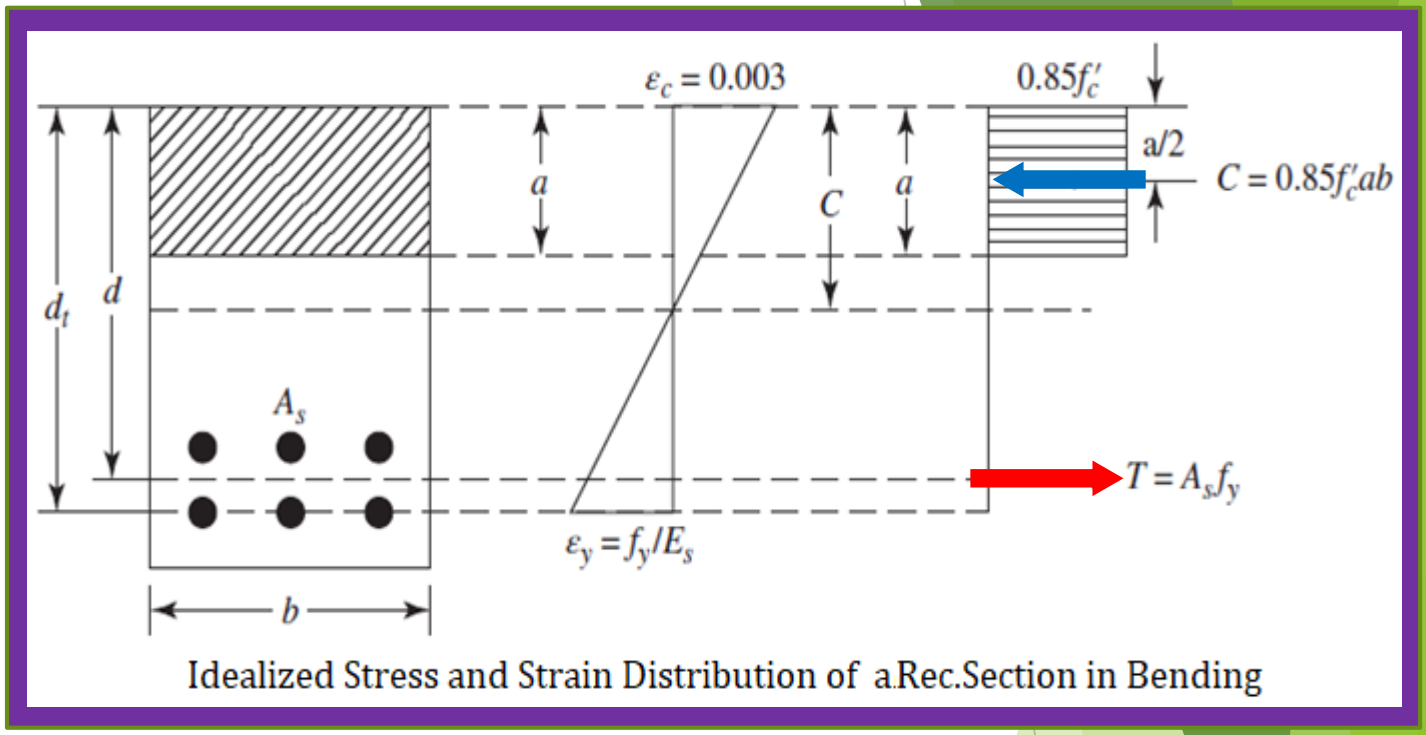


Typical Stress-Strain Curves for Concrete



Actual and Idealized Stress-Strain Curves for Steel





Idealized Stress and Strain Distribution of a Rec.Section in Bending

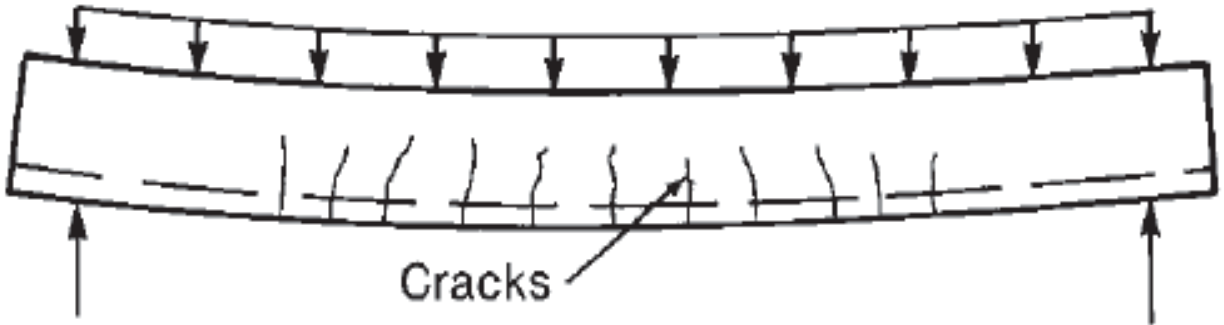
$$A_s\, f_y = 0.85\, f'_c\, a\, b \qquad (1)$$

$$M_n = A_s\, f_y \left(d - \frac{a}{2}\right) \qquad (OR) \qquad M_n = 0.85\, f'_c\, a\, b \left(d - \frac{a}{2}\right)$$

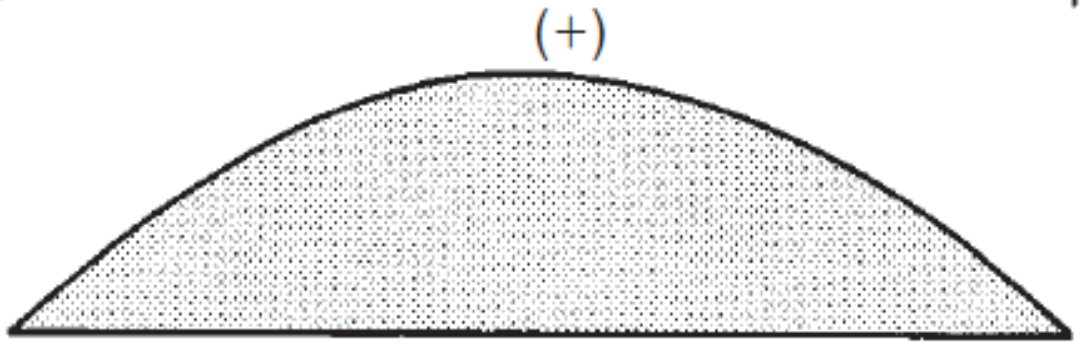
$$\varepsilon_t = 0.003 \left(\frac{d_t - c}{c}\right) \qquad (3)$$

$a = \beta_1 c$ *by definition:*

$$\beta_1 = \begin{cases} 0.85 & for\ f'_c \leq 28.0\ MPa \\ 0.85 - \dfrac{0.05\,(f'_c - 28)}{7} \not< 0.65 & for\ f'_c > 28.0\ MPa \end{cases}$$

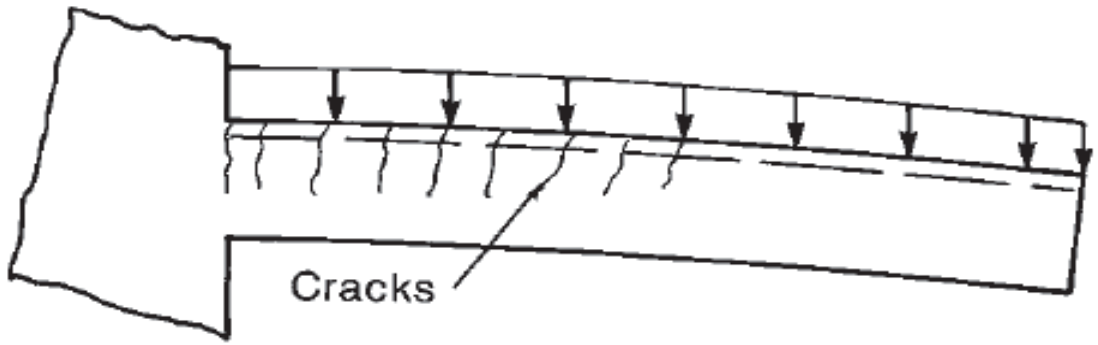


(a) Deflected shape.



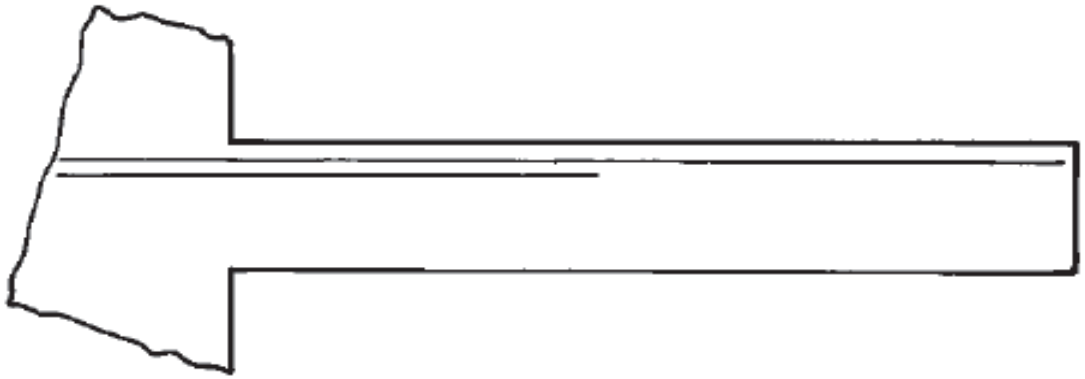
(b) Moment diagram.

(c) Reinforcement location.

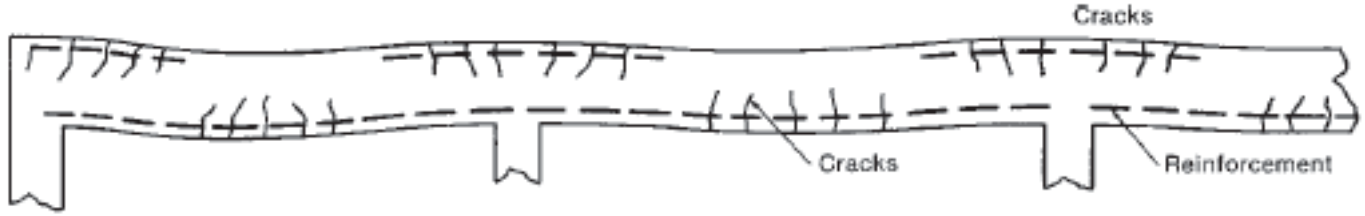


(a) Deflected shape.

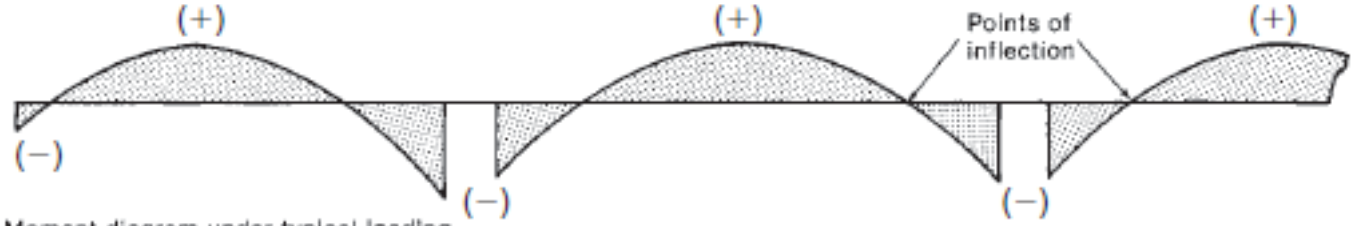
(b) Moment diagram.



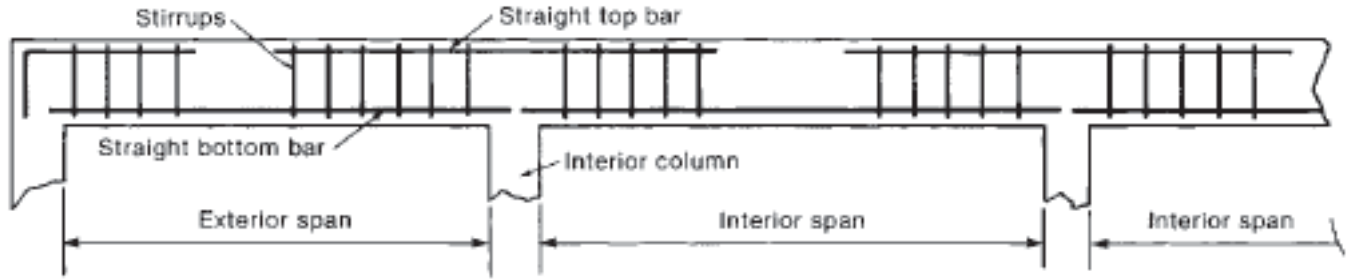
(c) Reinforcement location.



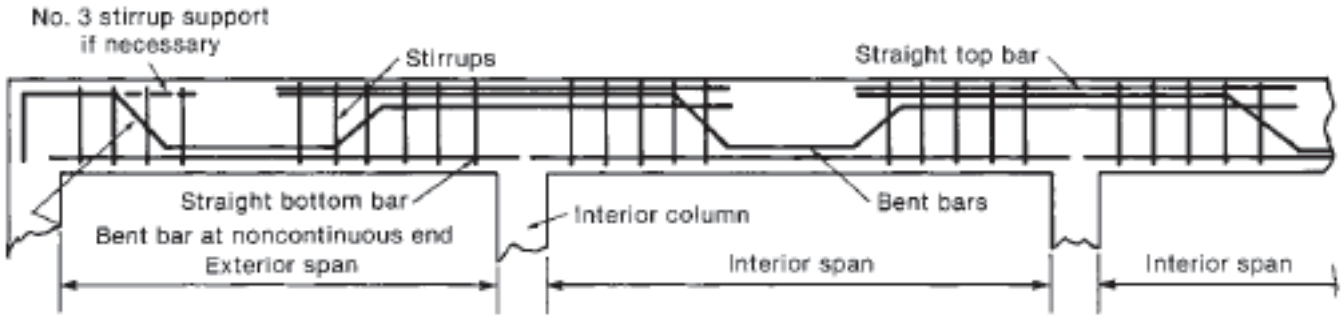
(a) Deflected shape.



(b) Moment diagram under typical loading.



(c) Straight bar reinforcement.



(d) Straight and bent bar reinforcement.