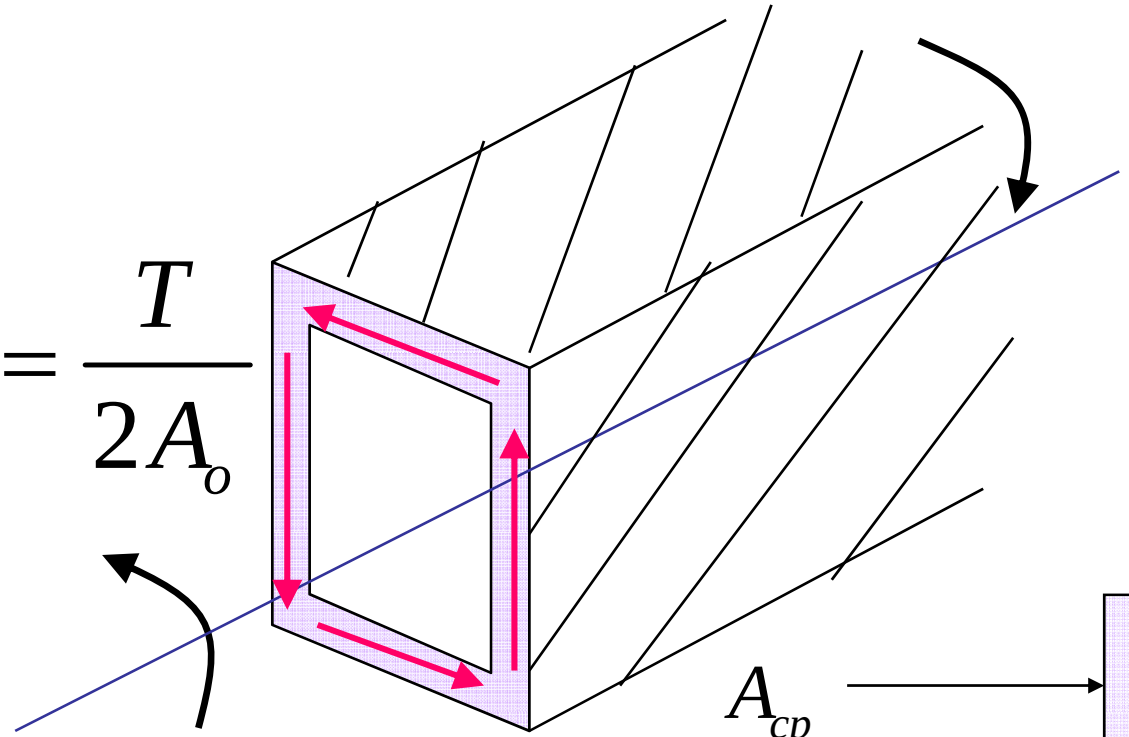
Beams in Torsion

- Space truss models
- Closed thin walled sections
- Extended application of beam models in shear

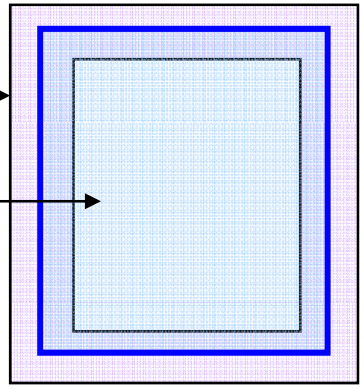
Torsional Strength Model

$$q = \frac{T}{2A_o}$$



A_{cp}

$A_0 = 0.85A_{oh}$

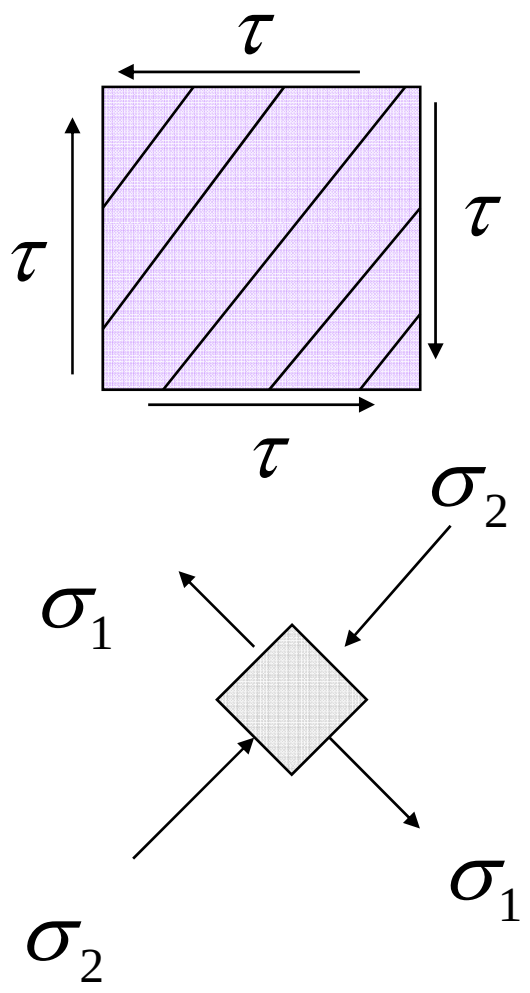


Cracking Torsional Limit

$$\sigma_1 = \tau = \frac{T}{2A_0 t}$$

$$t = \frac{3A_{cp}}{4p_{cp}}, A_0 = \frac{2}{3}A_{cp}$$

$$\sigma_1 = \tau = \frac{Tp_{cp}}{A_{cp}^2}$$



Cracking Torsion

$$\sigma_1 = \frac{1}{3}\sqrt{f_{ck}}$$

압축–인장 파괴 강도: 균열 비틀림

$$\sigma_1 = 0.7\sqrt{f_{ck}}$$

휨인장 파괴 강도: 균열 휨강도 산정

$$\sigma_1 = \frac{1}{6}\sqrt{f_{ck}}$$

압축–인장 파괴 강도: 전단 강도산정

$$T_{cr} = \frac{1}{6}\sqrt{f_{ck}}\left(\frac{A_{cp}^2}{p_{cp}}\right)$$

비틀림 효과 무시

$$T = \frac{1}{4} T_{cr}$$

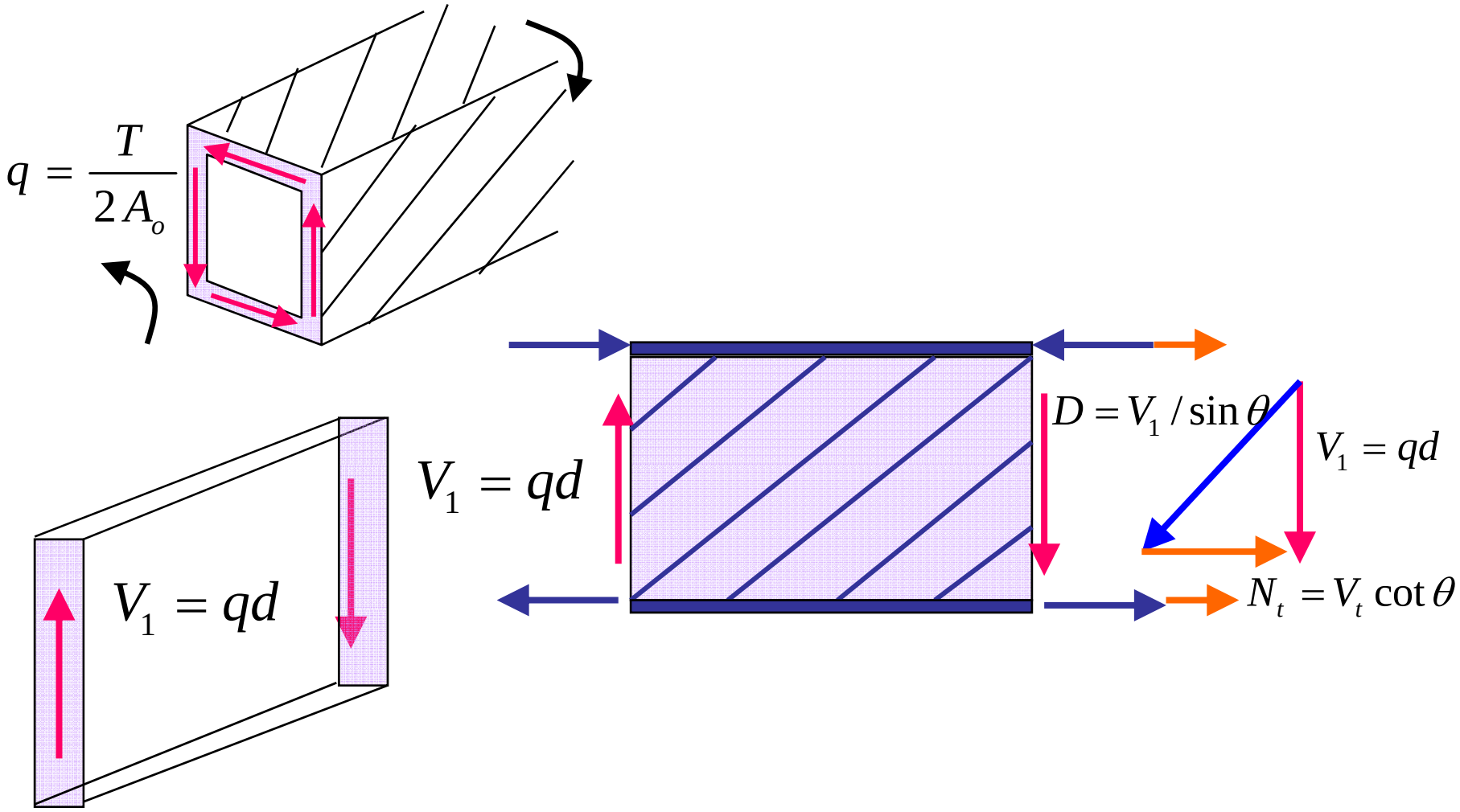
전단–비틀림 상관

$$\left(\frac{T}{T_{cr}}\right)^2 + \left(\frac{V}{V_{cr}}\right)^2 = 1$$

$$V = 0.97 V_{cr}$$

$$T_{th} = \phi \frac{\sqrt{f_{ck}}}{12} \left(\frac{A_{cp}^2}{p_{cp}}\right)$$

비틀림 강도



비틀림 강도

$$T = V_1 y_o + V_2 x_o$$

$$V_2 = \frac{A_t f_{yv} y_o}{s} \cot\theta$$

$$T_n = \frac{2 A_o A_t f_{yv}}{s} \cot\theta$$

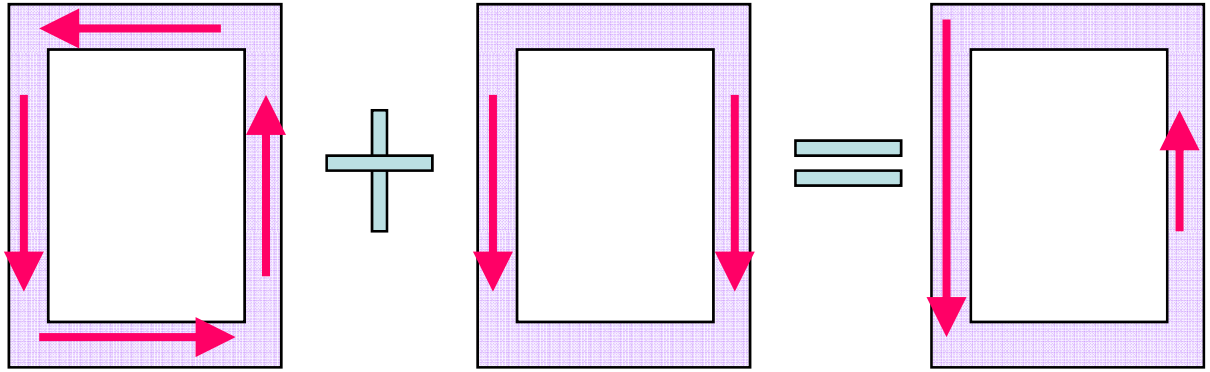
길이방향 철근

$$N = \frac{T_n}{2A_o} 2\left(x_o + y_o\right)\cot\theta$$

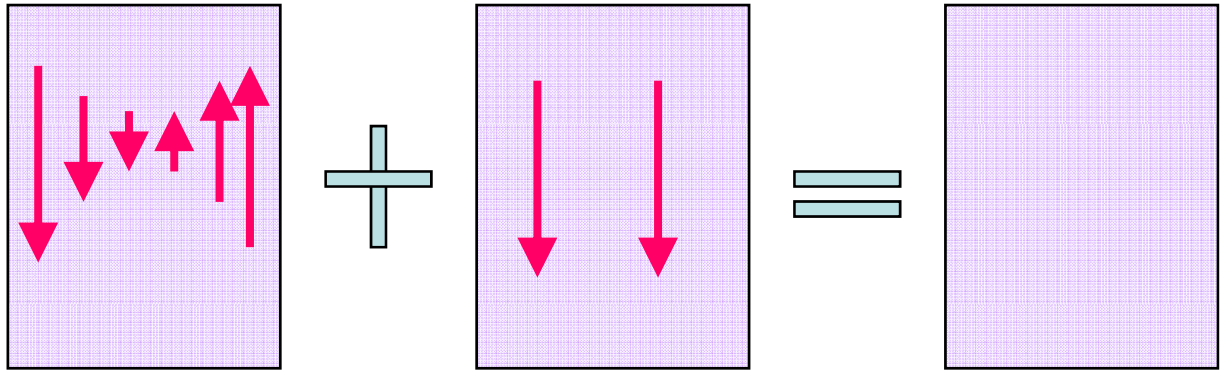
$$A_l f_{yl} = N$$

$$A_l = \frac{T_n p_h}{2A_o f_{fl}}\cot\theta$$

전단-비틀림 조합



Direct sum



Root-square sum

압축장의 압축파괴 한계

비틀림으로 유발된 압축응력

$$f_{cd} = \frac{V_2}{ty_o \cos\theta \sin\theta} = \frac{T_u p_h}{1.7 A_{oh}^2 \cos\theta \sin\theta}$$

전단력으로 유발된 압축응력

$$f_{cd} = \frac{V_u}{b_w d \cos\theta \sin\theta}$$

최소철근

$$A_v + 2A_t = \frac{1}{16}\sqrt{f_{ck}}\,\frac{b_w s}{f_{yv}} \geq \frac{b_w s}{3 f_{yv}}$$

$$A_{l,\min} = \frac{5\sqrt{f_{ck}}}{12 f_{yl}} A_{cp} - \left(\frac{A_t}{s}\right) p_h \left(\frac{f_{yv}}{f_{yl}}\right)$$