باسمه تعالی ۷/۲/۸۷

تحلیل و طراحی ستونها

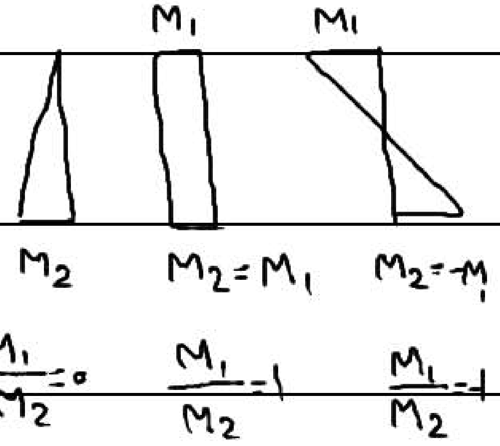
تعریف ستون : عضو فشاری + خمش

ستون ← کوتاه
ستون ← بلند ، لاغر

$\lambda = \frac{kl_u}{r} \leq 34 - 12\left(\frac{M_1}{M_2}\right)$ بدون انتقال جانبی

$r = \sqrt{\frac{I}{A}} \rightarrow 0.3h$ ، $0.25d$

$|M_2| > |M_1|$



$\lambda \leq 22$

خاموت (دورگیری) : جلوگیری از کمانش میلگردهای طولی

خاموت برشی

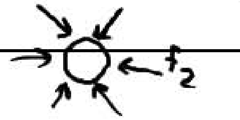
ثابت نگه داشتن قفسه میلگردهای طولی هنگام اجرا

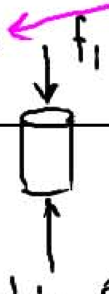
← تنگ دار
← مارپیچ

دورگیری بتن هسته مرکزی ← افزایش مقاومت بتن

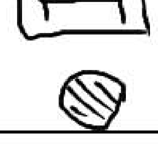
$f_1 = f_c + 4.1 f_2$

← افزایش شکل پذیری





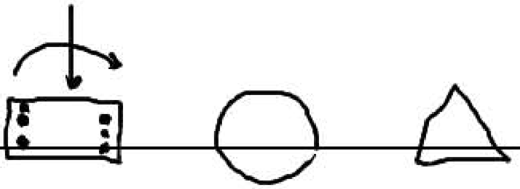
از نظر مسلح کردن ← میلگرد طولی
از نظر مسلح کردن ← پروفیل فولادی ← محیط / محاط



مسائل ← تحلیل : ظرفیت ستون با ابعاد و آرماتور مشخص پیدا کنیم

← طراحی

تحلیل ستون :



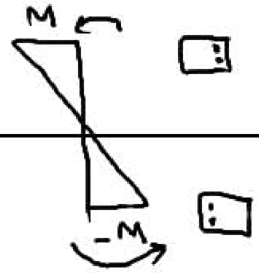
نیروی محور + خمش

دلایل متقارن آرماتورگذاری کردن ستونها :

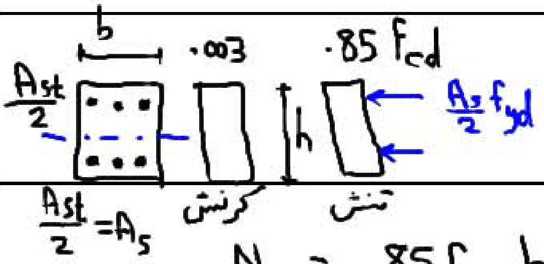
① لنگر بخاطر باد یا زلزله ±

② انحنای مضاعف در ستونها

③ سادگی اجرا

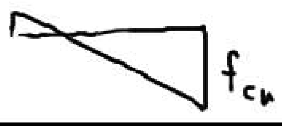


ستون : نیروی محوری + خمش



① ستون تحت اثر نیروی محوری

$$N_{r_{max}} = .85 f_{cd}\, bh + (f_{yd} - .85 f_{cd}) A_{st}$$



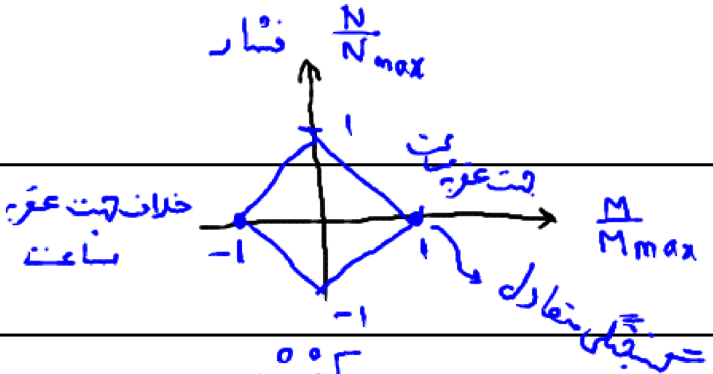
خمش + نیروی محور :

$$\frac{N}{A} + \frac{My}{I} = f_{cu} \longrightarrow \frac{N}{f_{cu} A} + \frac{M}{\frac{I f_{cu}}{y}} = 1$$

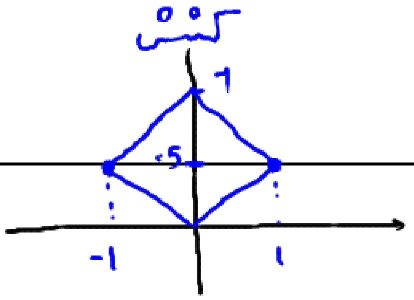
رابطه اندرکنش لنگر-نیروی محور

$$\frac{N}{N_{max}} + \frac{M}{M_{max}} = 1$$

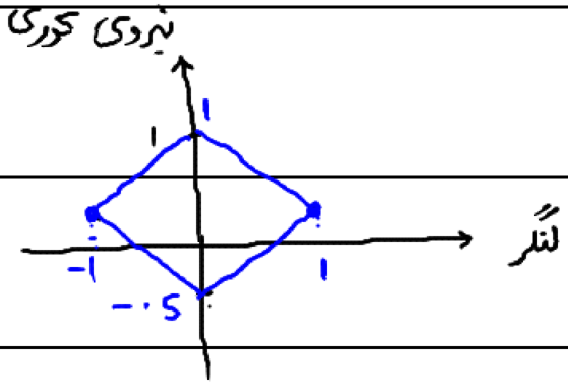
$$|f_{cu}| = |f_{tu}|$$



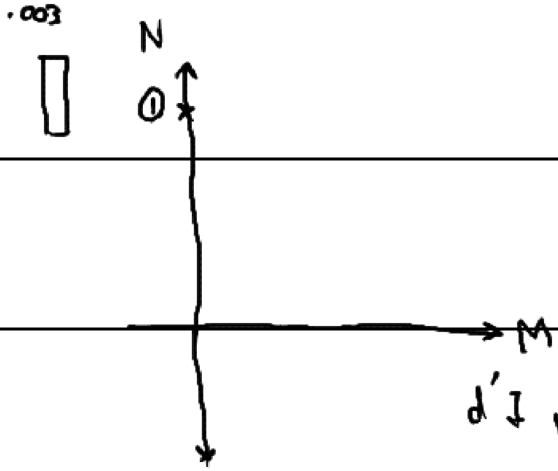
$$f_{tu} = 0$$



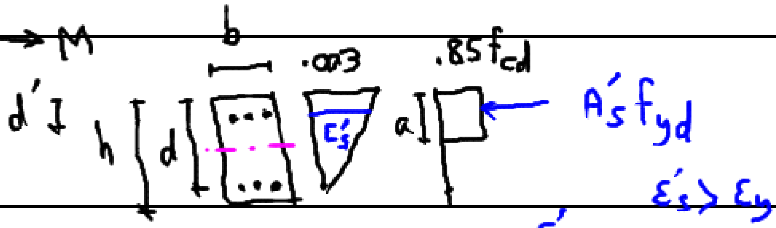
$$|f_{tu}| = .5\,|f_{cu}|$$



کشش $N_{r_{max}} = A_{st} f_{yd}$

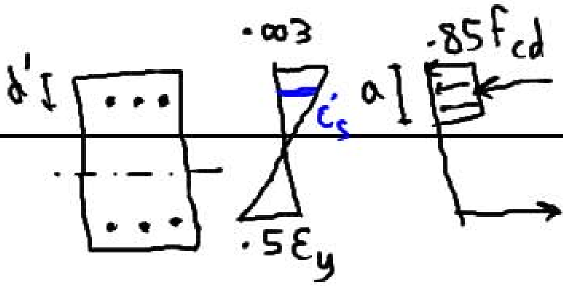


(۲)



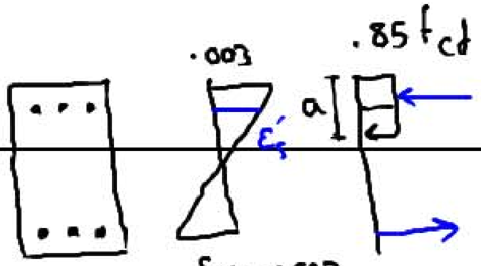
$$N_r = \overbrace{.85 f_{cd}\, ab}^{F_c} + \overbrace{(f_{yd} - .85 f_{cd})\, A'_s}^{F'_s}$$

$$M_r = F_c\left(\frac{h}{2} - \frac{a}{2}\right) + F'_s\left(\frac{h}{2} - d'\right)$$



$F'_s = A'_s(f_{yd} - .85 f_{cd})$ ③

$F_s = \varphi_s E_s (.5\varepsilon_y) A_s$



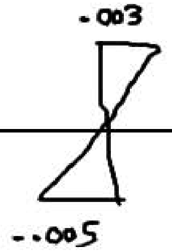
$F'_s = (f_{yd} - .85 f_{cd}) A'_s$

$F_c = .85 f_{cd}\, a\, b$ ④

$F_s = f_{yd} A_s$

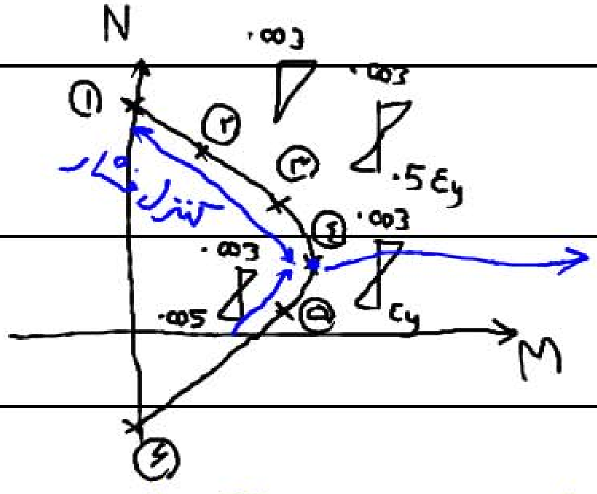
کشیدگی متعادل

$\varepsilon_y = .002 \rightarrow f_y = 400\ MPa$

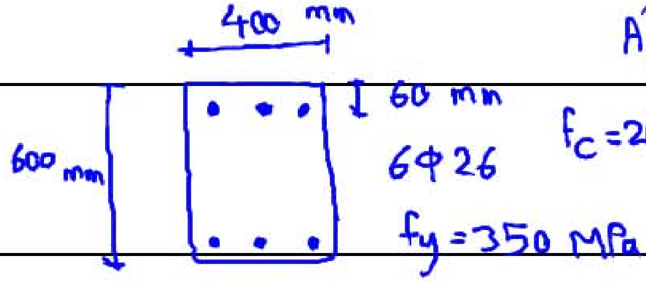


⑤

$N_{rt} = A_{st} f_{yd}$ کشش خالص ⑥



کشیدگی متعادل



$A'_s = A_s = 3\phi26 = 1593\ mm^2$

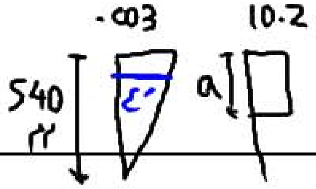
تحلیل مسئله:

$f_c = 20\ MPa \longrightarrow f_{cd} = 12\ MPa$

$f_{yd} = .85 \times 350 = 298\ MPa$

(1) $N_{r_{max}} = .85 \times 12\,(400 \times 600) + (298 - .85 \times 12)(2 \times 1593)$

$N_{r_{max}} = 3365$ KN.

(۲) 

$a = .85 \times 540 = 459$ mm

$.65 \leq \beta_1 = 1.09 - .008 f_c \leq .85$

$\frac{\varepsilon'_s}{.003} = \frac{480}{540} \longrightarrow \varepsilon'_s = .0027 > \varepsilon'_y = \frac{350}{200000} = .0018$

$F_c = 10.2 \times 400 \times 459 = 1873$ KN

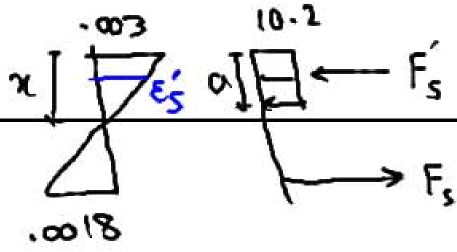
$F'_s = 1593\,(298 - 10.2) = 458$ KN

$F_s = 0$

$N_r = 1873 + 458 = 2331$ KN

$M_r = 1873\left(\frac{600}{2} - \frac{459}{2}\right) + 458\left(\frac{600}{2} - 60\right) = 242$ KN.m

| 2331 KN
| 242 KN.m

(4) 

$F_s = 1593 \times 298 = 475$ kN

$\frac{.003}{x} = \frac{.0018}{540 - x} = \frac{.0048}{540} \longrightarrow x = 338$ mm

$a = \beta_1 x = .85 \times 338 = 287$ mm $\qquad F_c = 10.2 \times 400 \times 287 = 1171$ KN

$$\frac{\varepsilon_s'}{.003} = \frac{278}{338} \longrightarrow \varepsilon_s' = .0025 > .0018$$

$F_s' = 1593\,(298 - 10.2) = 458$ KN

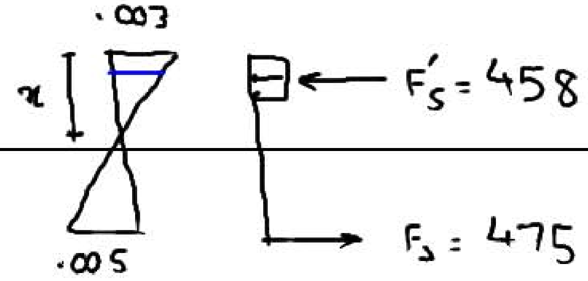
$N_r = 1171 + 458 - 475 = 1154$ KN

$M_r = 1171\left(300 - \frac{287}{2}\right) + 458\,(300-60) + 475\,(300-60)$

$M_r = 407$ KN.m

1154 KN
407 KN.m

⑤



$$\frac{.003}{x} = \frac{.005}{540 - x} = \frac{.008}{540}$$

$x = 203$ mm

$a = .85 \times 203 = 172$ mm

$F_c = 10.2 \times 400 \times 172 = 702$ KN

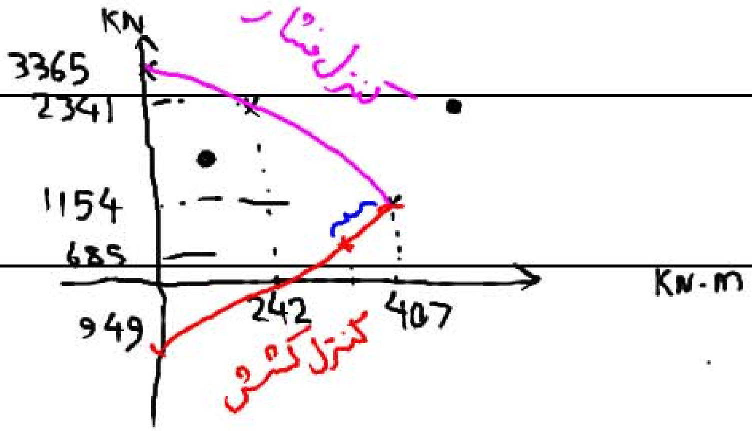
$N_r = 458 + 702 - 475 = 685$ KN

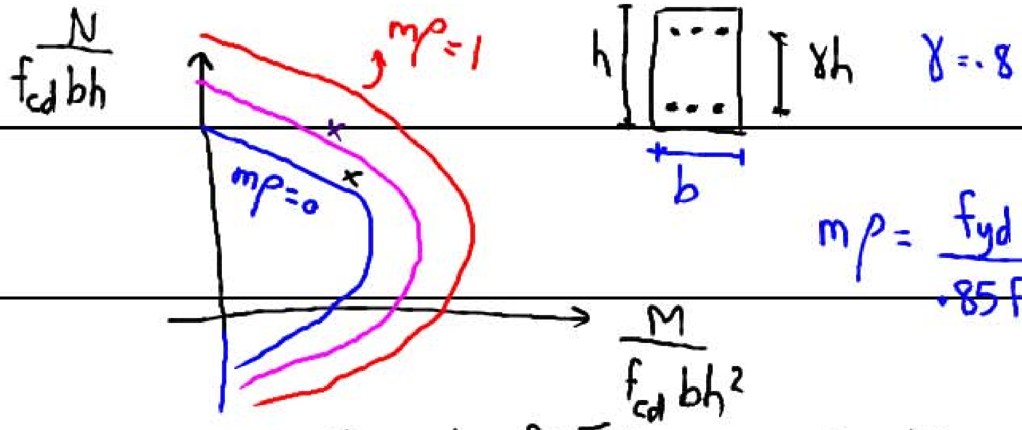
$M_r = 702\left(300 - \frac{172}{2}\right) + 458\,(300-60) + 475\,(300-60)$

$M_r = 374$ KN.m

685 KN
374 KN·m

⑦ $N_r = (1593 \times 2) \times 298 = 949$ KN





$$m\rho = \frac{f_{yd}}{.85 f_{cd}} , \frac{A_{st}}{A_g}$$

طراحی: استفاده از نمودارهای اندرکنش بی‌بعد شده