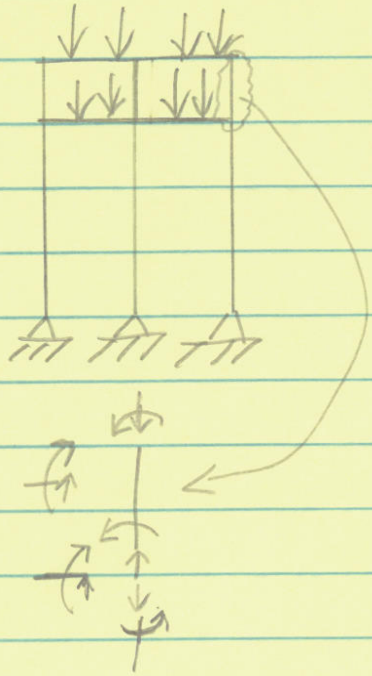
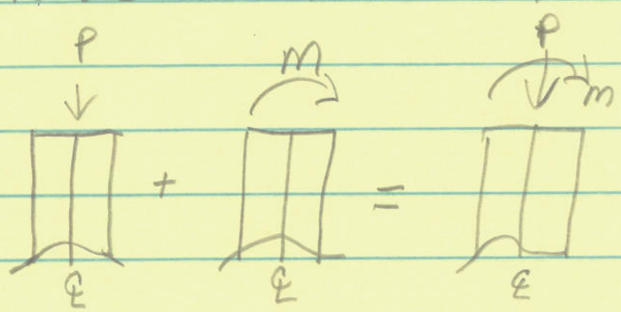
Colums

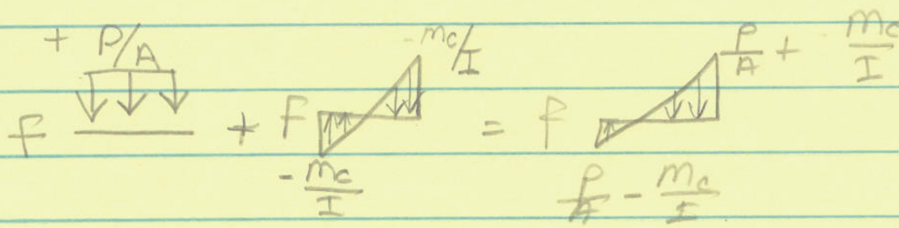
Columns
Interactions
Concrete Reality
Interaction diagram
Example
Slenderness
Sway
Design

Wed 10-20 Review
Mon 10-25 ACI
Wed 10-27 Exam



Stresses in Normal Columns





P&M Interact to determine f

Interaction Equations

Assume linear Elastic homogeneous prismatic

$\frac{P}{A} + \frac{Mc}{I} \le F_{max}$ (some max stress levels)

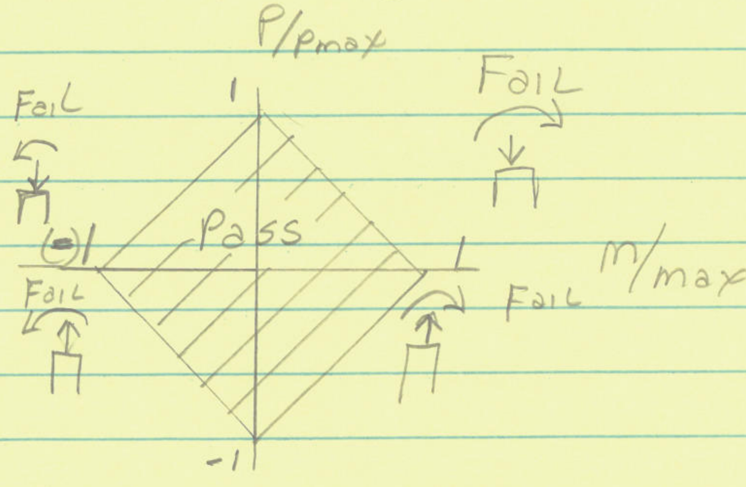
divide by Fmax

$\frac{P}{(A)F_{max}} + \frac{Mc}{(I)F_{max}} \le 1.0$

~~$\frac{P_{max}}{A}$~~ $\qquad \frac{M_{max}C}{I}$

$\frac{P}{P_{max}} + \frac{M}{M_{max}} \le 1.0$

Interaction Diagram



Assuming $f_{max\,t} = f_{max\,c}$

Back to Reality

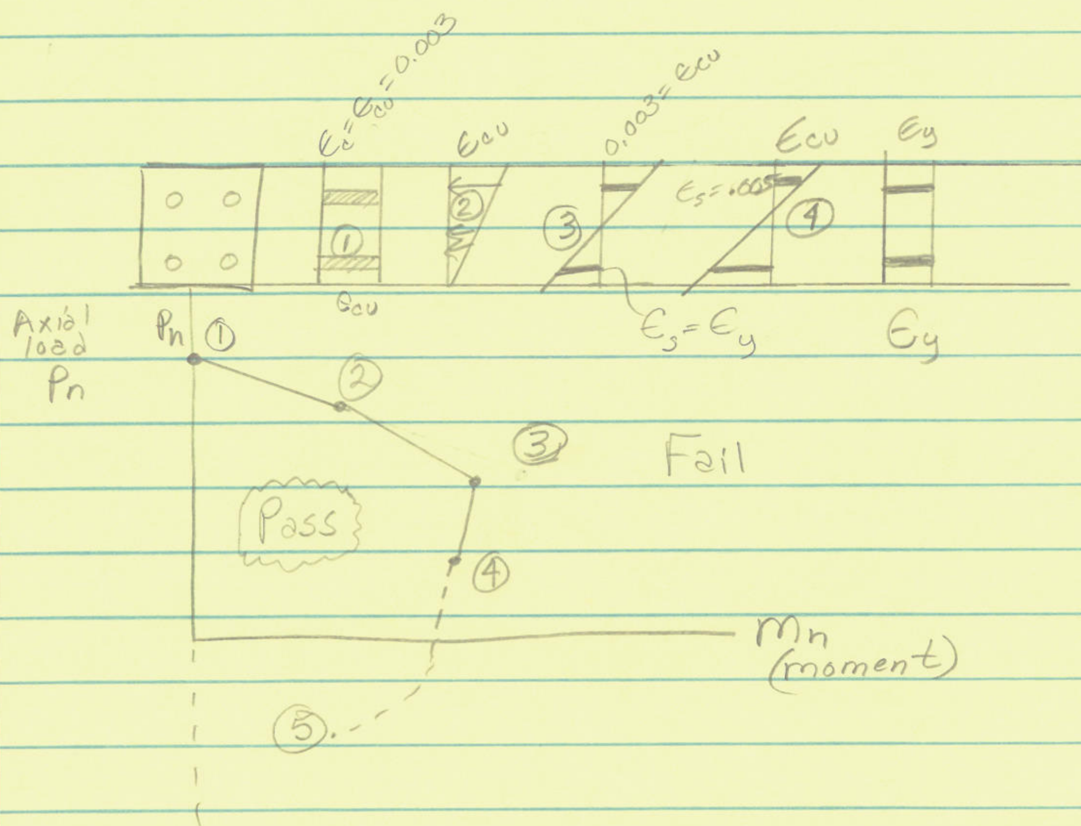
RC is not homogenous

RC Simplified Interaction Diagram

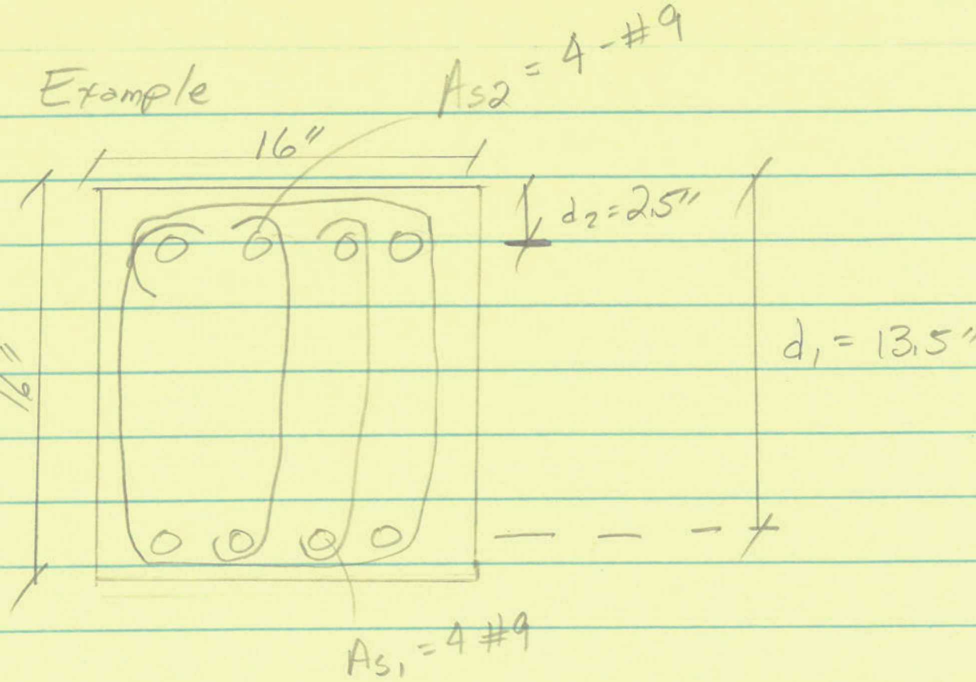
Build w/5 key Points

ϵ_{cu} 0.003
concrete Ultimate

1. Uniform compression $\epsilon_c = \epsilon_{cu}$
2. $\epsilon_{top} = \epsilon_{cu}$, $\epsilon_{bottom} = 0$
3. Balanced: $\epsilon_{top} = \epsilon_{cu}$, $\epsilon_s = \epsilon_y$
4. $\epsilon_{top} = \epsilon_{cu}$, $\epsilon = 0.005$
5. Uniform tensile strain $\epsilon = \epsilon_y$



Example



Compute 4 points on the interaction diagram

$f'_c = 5ksi$

$f_y = 60ksi$

gross Area bh $A_g = bh = 256\ in^2$

$A_{s1} = 4\ in^2$

$A_{s2} = 4\ in^2$

$A_{ST} = 8\ in^2$

$\rho_{ST} = \dfrac{A_{ST}}{A_g} = 0.031$

Point 1 uniform compression

$\epsilon_c = \epsilon_{cu} = 0.003 \qquad \epsilon_s = 0.003 > \epsilon_y$

Columns with spirals Reinforcement

[10.3.6.1]

more $

Better in seismic regions

Colums with Tie Reinforcement

[10.3.6.2]
less $

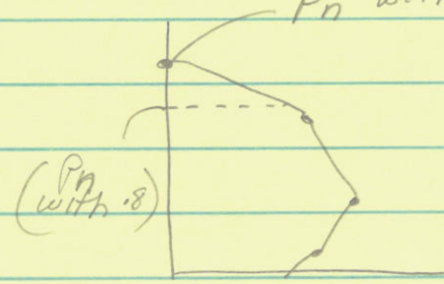
$\phi P_n = 0.80 \phi [0.85 f'_c (A_g - A_{ST}) + f_y A_s]$

(concrete: $0.85 f'_c (A_g - A_{ST})$; steel: $f_y A_s$)

$\phi = 0.65$ [9.3.2.2] compression tied

$= 0.8\phi [0.85(5000)(256-8) + 60,000(8)]$

$P_n = 1534$ kips
$\phi P_n = 997$ kips

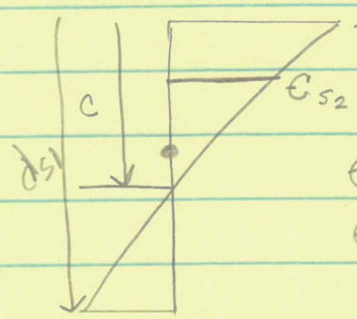


ϕ Factors

IAD point		ϕ
Compression TIED	1	
	2	TIED = 0.65
	3	SPIRAL = 0.70
Transition [R 9.3.2] →	4	
tension	5	0.9

Pt 2,3,4

Point 3 balanced



$\epsilon_c = \epsilon_{cu} = 0.003$

$\epsilon_{s1} = \epsilon_y$

$\epsilon_{s1} = 0.00207 = \epsilon_y$

determine NA Neutral Axis

$$\frac{\epsilon_{cu}}{c} = \frac{\epsilon_{s1} + \epsilon_{cu}}{d_{s1}}$$

$$c = \frac{\epsilon_{cu}\, d_{s1}}{\epsilon_{s1} + \epsilon_{cu}} = \frac{0.003\,(13.5)}{0.0027 + 0.003}$$

$c = 7.99\,in$

determine force resultants

$a = \beta_1 c = 0.8\,(7.99) = 6.39\,in$

(if $a > h$, use h)

Compression steel — $C_c = 0.85 f'_c a b = 0$

$= 434.6\,k$

$T_s = f_{s1} A_s = -60\,(4) = -240^k$

$C_s = (f_{s2} - 0.85 f'_c)\, A_{s2}$

$C_s = (59.8 - 0.85(5\,ksi))(4) = 221k$ calculate ϵ_{s2} then calc f_{s2}

Calculate P_n, M_n

$P_n = C_c + \Sigma F_{s2} = 434.6 + 222.1 - 24$

$P_n = 417\ k$

ΣM @ centroid

$M_n = C_c(h/2 - a/2) + F_{s1}(h/2 - d_1)\ d_1 + F_{s2}(\frac{h}{2} - d_2)$

$(P_n, M_n)_3 = (417, 4630)$