	COMPANY NAME				Calculation No. CALCULATION NUMBER			
	CALCULATION SHEET		Project No.					
	onlinestructuraldes	sign.com	F	ROJECT NUN	/IBER			
Project Title:	Project Name		Calc. By	Date	Rev.			
			Author	today	0			
Subject	Reinforced Concrete Column Capacity - Axial Force Bending Moment		Ckd. By	Date				
	Interaction (ACI318)		Checker	today				

<u>Input</u>	<u>Output</u>
Column dimensions	Moment capacity
Reinforcement	Column interaction diagram
Materials (steel, concrete, bolts)	

RC Column Capacity - Axial Force - Bending Moment Interaction (ACI 318)

Axial force - bending moment interaction - ultimate limit state

Column dimensions

h =	10 in
b =	18 in
_ h * h _	100 in ²

RC Element Area

Reinforcement

cover	2.44 in	cover to the center of the bars
d =	7.56 in	depth of bottom reinforcement (h- cover)
$d_c =$	2.44 in	depth of top reinforcement (h- cover)

Tension side reinforcement

	#	9	bar size
n =		3	no of bars

$$A_s = 3.00 \text{ in}^2$$
 area of tension reinforcement $\rho_{\text{tens,reinf}} = 1.67 \%$ percentage of tension reinforcement

Compression side reinforcement

Compression side	remnorcement	
#	9	bar size
n =	3	no of bars
$A_{s.b} =$	3.00 in ²	area of compression reinforcement
$\rho_{comp.reinf}$ =	1.67 %	percentage of compression reinforcement
$A_{s.t} = A_s + A_{s.b} =$	6.00 in ²	total area of reinforcement
ρ =	3.33 %	element total percentage of reinforcement

per ACI 318 Section 10.9.1

Reinf percentage should be between 0.01Ag and 0.08Ag

Confinement reinforcement (tied or spiral)

tied

Materials

Concrete

 f_c ' = 4 ksi concrete characteristic cylinder strength

reinforcement yield strength

Reinforcement type

 $\begin{array}{c} A 615 \\ \text{Grade} \\ f_{y} = 60 \text{ ksi} \end{array}$

see reinforcement types here

References:

ACI318-05 - Building code requirements for structural concrete

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Calculation No. COMPANY NAME **CALCULATION NUMBER CALCULATION SHEET** Project No. PROJECT NUMBER onlinestructuraldesign.com Project Name Project Title: Calc. By Date Rev. Author today 0 Reinforced Concrete Column Capacity - Axial Force Bending Moment Subject Ckd. By Date Interaction (ACI318) Checker today

Reinforcement modulus of elasticity

 $E_s =$

29000 ksi

per ACI 318 Section 8.5.2

Modulus of elasticity of reinforcement

Yield reinforcement strain:

 $f_y / E_s =$

0.002

The relationship between concrete compressive stress and concrete strain is satisfied by an equivalent rectangular concrete stress distribution defined by a $0.85 \, {}^{*}\xi^{*}$ uniform stress over an equivalent compression zone bounded by edges of the cross section and a straight line located parallel to the neutral axis at a distance $a = \beta_1 \, {}^{*}c$ from the fiber of maximum compressive strain.

per ACI 318-05

Sections 10.2.6 and 10.2.7

Section strength reduction factor

φ =

0.90 For tension controlled sections

0.70 C

Compression controlled section with spiral reinforcement

0.65

Compression controlled section other reinforced members

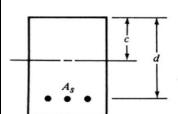
per ACI 318-05

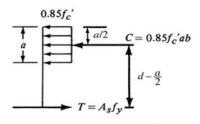
Section 9.3

Values of $\boldsymbol{\varphi}$ strength reduction factor

Maximum usable strain at extreme concrete compression fiber

is 0.003





per ACI 318-05 Section 10.2.3

Maximum usable strain at extreme concrete compression fiber shall be assumed equal to 0.003; The relation between concrete compressive stress and concrete strain is assumed rectangular

Section 10.2.7.1

 $0.85f_c^+$ value uniformly distributed over an equivalent compression zone bounded by edges of the cross section and a straigth line located parale to the neutral axis at a distance $a=\beta_1^*c$ from the fiber of max. compression strain

 $\beta_1 = 0.85$

 $\beta_1 * c$

factor relating depth of equivalent rectangular compressive stress block

to neutral axis depth

per ACI 318-05 Section 10.2.7.3

between 2500 and 4000 psi b1 = 0.85, above 4000 β_1 will be reduced lineary at a rate of 0.05 per 1000 psi but not

lower than 0.65

depth of equivalent rectangular stress block

Section 10.2.7.1

Section 10.2.3

stress in reinforcement below f_{ν} shall be taken as E_s times steel strain. For strains greater than that corresponding to fy, stress in reinforcement shall be considered independent of strain and equal to f_{ν} .

References:

ACI318-05 - Building code requirements for structural concrete

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Project Title:	Project Name				Onlin	estructuraldesign.com	Calc. By	Date	Rev.
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Subject	Reinforced Concrete C	Column Capaci	ty - Axial F	orce Bend	ing Mom	ent	Ckd. By	Date	
	Interaction (ACI318)						Checker	today	
Point 1 - Pure co	0.65 compression	controlled secti	ion			Section stren	gth reduction facto	r	
Ψ –	0.03 compression	controlled seen	011			Section streng	gtirreduction racto		
$\phi P_{n,max} =$	0.80 φ[0.85f _c '(A _g -A	$_{st})+f_{y}A_{st}]$				per ACI 33	18		
						eq. 10-1 a	ind 10-2		
$\phi P_{n,max} =$	494.83 kips					Maximum all	owable value of the	nominal axial st	rength
_						of cross section	on multiplied by th	e strength reduc	tion factor
Point 2 - f _s = 0		0.000							
Concrete strain: The neutral axis i	is located in the center of	0.003 the hottom rein	nforcement				reached ultimate of shortening strain as		
C =		.56 in	orcement			·	ocation - in this cas	-	:
						the bottom re			
Top reinforceme	ent strain (compression):	0.003 *	$(c-d_c)/c=$	0.0020					
Yield reinforcem	ent strain:	0.002			=>	Compression reinfor	rcement has n	ot reached y	ield
φ =	0.65 compression	controlled secti	ion			Section stren	gth reduction facto	r	
a =	$\beta_1 * c = 6$.43 in d	depth of equ	uivalent red	ctangular				
			tress block						
$\phi P_n =$	φ * [0.85* f _c ' * a *	b + 0.002	2*Es*	A _{s.b}]					
$\phi P_n =$	370.52 kips								
• •	·								
$\phi M_n =$	1 1 1/2 0 -								
	φ* [(0.85	* f _c ' * a * b) * (l	h/2 - a/2) +	(0.002	2*Es*	$A_{s.b}$) * (h/2 - d_c)]			
4N4 -		* f _c ' * a * b) * (l	h/2 - a/2) +	(0.002	2*Es*	$A_{s.b}$) * (h/2 - d_c)]			
$\phi M_n =$	φ * [(0.85	* f _c ' * a * b) * (l	h/2 - a/2) +	(0.002	2*Es*	$A_{s.b}$) * (h/2 - d_c)]			
	62.58 ft -kips	* f _c ' * a * b) * (I	h/2 - a/2) +	(0.002	2*Es*	$A_{s,b}$) * (h/2 - d_c)]			
Point 3 - f _s = 0.5	62.58 ft -kips	* f _c ' * a * b) * (l	h/2 - a/2) +	(0.002	2*Es*		reached ultimate c	oncrete design	
$\phi M_n =$ Point 3 - $f_s = 0.5$ Concrete strain:	62.58 ft -kips	0.003		(0.00	2*Es*	Concrete has	reached ultimate c shortening strain a	_	
Point 3 - f _s = 0.5 Concrete strain:	62.58 ft -kips * f _y ement strain (tension):			0.0010	2*Es*	Concrete has		_	
Point 3 - f _s = 0.5 Concrete strain:	62.58 ft -kips * f _y	0.003			2*Es*	Concrete has compressive		and $f_s = 0.5 * f_y$	
Point 3 - $f_s = 0.5$ Concrete strain: Bottom reinforce c =	62.58 ft -kips * f _y ement strain (tension): 5.62 in	0.003 $\varepsilon_{\rm t}$ = (0.5 * f	F _y) / E _s =	0.0010	2*Es*	Concrete has compressive	shortening strain a	and $f_s = 0.5 * f_y$	
Point 3 - f _s = 0.5 Concrete strain: Bottom reinforce c =	* f _y ement strain (tension): 5.62 in ent strain (compression):	0.003 $\epsilon_{\rm t} = (0.5 * f_{\rm t})^{-1}$ 0.003 $*$				Concrete has compressive From the rela	shortening strain a	and $f_s = 0.5 * f_y$.003 / ϵ_t	ield
Point 3 - $f_s = 0.5$ Concrete strain: Bottom reinforce c =	* f _y ement strain (tension): 5.62 in ent strain (compression):	0.003 $\varepsilon_{\rm t}$ = (0.5 * f	F _y) / E _s =	0.0010	2*Es* =>	Concrete has compressive	shortening strain a	and $f_s = 0.5 * f_y$.003 / ϵ_t	ield
Point 3 - $f_s = 0.5$ Concrete strain: Bottom reinforce c =	* f _y ement strain (tension): 5.62 in ent strain (compression):	0.003 $\epsilon_{\rm t}$ = (0.5 * f 0.003 * 0.002	f _y) / E _s = *(c-d _c)/c =	0.0010		Concrete has compressive From the rela Compression reinfor	shortening strain a	and $f_s = 0.5 * f_y$ $.003 / \varepsilon_t$ ot reached y	ield
Point 3 - $f_s = 0.5$ Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme	* f _y ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression	0.003 $\epsilon_{t} = (\ 0.5 * f$ $0.003 *$ 0.002 controlled secti	f _y) / E _s = *(c-d _c)/c = ion	0.0010	=>	Concrete has compressive From the rela Compression reinfor	shortening strain a strain $[c/(d-c)] = 0$	and $f_s = 0.5 * f_y$ $.003 / \varepsilon_t$ ot reached y	ield
Point 3 - f _s = 0.5 Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme	* f _y ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression	0.003 $\epsilon_{\rm t}$ = (0.5 * f 0.003 * 0.002 controlled secti	f _y) / E _s = *(c-d _c)/c = sion depth of equ	0.0010	=>	Concrete has compressive From the rela Compression reinfor	shortening strain a strain $[c/(d-c)] = 0$	and $f_s = 0.5 * f_y$ $.003 / \varepsilon_t$ ot reached y	ield
Point 3 - f _s = 0.5 Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme ϕ = a =	62.58 ft -kips * $\mathbf{f_v}$ ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression $\beta_1 * c = 4$	0.003 $\epsilon_{\rm t} = (~0.5~{}^{*}~{\rm f}$ $0.003~{}^{*}$ 0.002 controlled sections.78 in a constant of the sections of the section of the sec	f _y)/E _s = *(c-d _c)/c = tion depth of equences block	0.0010 0.0017	=> ctangular	Concrete has compressive From the rela Compression reinfor	shortening strain a strain $[c/(d-c)] = 0$	and $f_s = 0.5 * f_y$ $.003 / \varepsilon_t$ ot reached y	ield
Point 3 - $f_s = 0.5$ Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme	* f _y ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression	0.003 $\epsilon_{\rm t} = (~0.5~{}^{*}~{\rm f}$ $0.003~{}^{*}$ 0.002 controlled sections.78 in a constant of the sections of the section of the sec	f _y)/E _s = *(c-d _c)/c = tion depth of equences block	0.0010	=> ctangular	Concrete has compressive From the rela Compression reinfor	shortening strain a strain $[c/(d-c)] = 0$	and $f_s = 0.5 * f_y$ $.003 / \varepsilon_t$ ot reached y	ield
Point 3 - f _s = 0.5 Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme ϕ = a =	62.58 ft -kips * $\mathbf{f_v}$ ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression $\beta_1 * c = 4$	0.003 $\epsilon_{\rm t} = (~0.5~{}^{*}~{\rm f}$ $0.003~{}^{*}$ 0.002 controlled sections.78 in a constant of the sections of the section of the sec	f _y)/E _s = *(c-d _c)/c = tion depth of equences block	0.0010 0.0017	=> ctangular	Concrete has compressive From the rela Compression reinfor	shortening strain a strain $[c/(d-c)] = 0$	and $f_s = 0.5 * f_y$ $.003 / \varepsilon_t$ ot reached y	ield
Point 3 - f_s = 0.5 Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme ϕ = a = ϕP_n =	62.58 ft-kips * $\mathbf{f_y}$ ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression $\beta_1 * c = 4$ $\phi * [0.85* f_c' * a *$	0.003 $\epsilon_{\rm t} = (~0.5~{}^{*}~{\rm f}$ $0.003~{}^{*}$ 0.002 controlled sections.78 in a constant of the sections of the section of the sec	f _y)/E _s = *(c-d _c)/c = tion depth of equences block	0.0010 0.0017	=> ctangular	Concrete has compressive From the rela Compression reinfor	shortening strain a strain $[c/(d-c)] = 0$	and $f_s = 0.5 * f_y$ $.003 / \varepsilon_t$ ot reached y	ield
Point 3 - $f_s = 0.5$ Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme $\phi =$ a = $\phi P_n =$	62.58 ft-kips * $\mathbf{f_v}$ ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression $\beta_1 * c = 4$ $\phi * [0.85* f_c' * a * 227.60 \text{ kips}]$	$0.003 \\ \epsilon_{\rm t} = (\ 0.5\ *\ f \\ 0.003\ * \\ 0.002 \\ \\ \text{controlled secti} \\ .78\ in & s \\ b + & 0.001 \\ \\ \end{array}$	f _y)/E _s = *(c-d _c)/c = ion depth of equatress block 7*Es*	0.0010 0.0017 uivalent rec $A_{s,b}$ - ε_t * [=> ctangular = _s * A _s]	Concrete has compressive From the rela Compression reinfor	shortening strain a stion [c / (d - c)] = 0 rcement has n gth reduction facto	and $f_s = 0.5 * f_y$ $0.003 / \varepsilon_t$ ot reached y	ield
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Point 3 - $f_s = 0.5$ Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme $\phi =$ a = $\phi P_n =$ $\phi P_n =$	62.58 ft-kips * $\mathbf{f_v}$ ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression $\beta_1 * c = 4$ $\phi * [0.85* f_c' * a * 227.60 \text{ kips}]$	$0.003 \\ \epsilon_{\rm t} = (\ 0.5\ *\ f \\ 0.003\ * \\ 0.002 \\ \\ \text{controlled secti} \\ .78\ in & s \\ b + & 0.001 \\ \\ \end{array}$	f _y)/E _s = *(c-d _c)/c = ion depth of equatress block 7*Es*	0.0010 0.0017 uivalent rec $A_{s,b}$ - ε_t * [=> ctangular = _s * A _s]	Concrete has compressive From the rela Compression reinfor Section stren	shortening strain a stion [c / (d - c)] = 0 rcement has n gth reduction facto	and $f_s = 0.5 * f_y$ $0.003 / \varepsilon_t$ ot reached y	ield
Point 3 - $f_s = 0.5$ Concrete strain: Bottom reinforce c = Top reinforceme Yield reinforceme $\varphi =$ a = $\varphi P_n =$ $\varphi P_n =$ $\varphi M_n =$	62.58 ft -kips * $\mathbf{f_y}$ ement strain (tension): 5.62 in ent strain (compression): ent strain: 0.65 compression $\beta_1 * c = 4$ $\phi * [0.85* f_c' * a * 227.60 kips$ $\phi * [(0.85* f_c' * 3.85* f_c' $	$0.003 \\ \epsilon_{\rm t} = (\ 0.5\ *\ f \\ 0.003\ * \\ 0.002 \\ \\ \text{controlled secti} \\ .78\ in & s \\ b + & 0.001 \\ \\ \end{array}$	f _y)/E _s = *(c-d _c)/c = ion depth of equatress block 7*Es*	0.0010 0.0017 uivalent rec $A_{s,b}$ - ε_t * [=> ctangular = _s * A _s]	Concrete has compressive From the rela Compression reinfor Section stren	shortening strain a stion [c / (d - c)] = 0 rcement has n gth reduction facto	and $f_s = 0.5 * f_y$ $0.003 / \varepsilon_t$ ot reached y	ield

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Project Title:	Project Name						lc. By	Date	Rev.
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Subject	Reinforced Concrete Col	lumn Capacity - Axi	al Force Bend	ding Mom	ent	Ck	d. By	Date	
	Interaction (ACI318)						Checker	today	
	(Dalaman da adad)								
	Balanced point)	0.003			-	er ACI 318-05	•		
Concrete strain:		0.003				ection 10.3.2	ed ultimate (oncrete design	1
Rottom reinforc	ement strain (tension):	$\varepsilon_t = f_v / E_s =$	0.0021			ompressive shorte		ū	
3000000	cinent strain (tension).	,,,,	0.0021			aches the strain c			
								, , ,	
c =	4.47 in				Fi	om the relation [c	/(d - c)] = 0	.003 / $\varepsilon_{\rm t}$	
		*/1 \ /-		İ					
•	ent strain (compression):	0.003 *(c-d _c)/c	= 0.0014		Compressio	n reinforcem	ant has n	at raachad	viold
rield reinforcem	ient strain:	0.002		=>	Compressio	n reinforcem	ent nas n	ot reached	yieid
φ =	0.65 compression co	ntrolled section			Se	ection strength rec	duction facto	r	
'	·					Ţ.			
a =	$\beta_1 * c = 3.80$	0 in depth of	f equivalent re	ctangular					
		stress bl							
$\phi P_n =$	φ * [0.85* f _c ' * a * b -	+ 0.0014*Es*	$A_{s.b}$ - $f_y * A$	A _s]					
1.0	444.40.11								
$\phi P_n =$	111.42 kips								
φ M _n =	# [(O 8E* f	f _c ' * a * b) * (h/2 - a/2	2) + / 0 001	1.4*=c*			* / . . / .	D\1	
ψι ν ι _n –	ψ [(0.03)]	i _c a b) (11/2-a/			Λ */h/2	- 4) + f * v			
			2) 1 (0.001	L4 · ES ·	A _{s.b}) * (h/2	$- d_c) + f_y * A_s$	* (a - n/2	-/]	
φ M _n =	80.48 ft -kips		2) 1 (0.001	14°ES°	A _{s.b}) * (h/2	- d _c) + f _y * A _s	* (a - n/2	-/)	
$\phi M_n =$	80.48 ft -kips		2) 1 (0.003	14 ES	A _{s.b}) * (h/2	- d _c) + f _y * A _s	* (a - n/2	-/1	
	·				A _{s.b}) * (h/2	- d _c) + f _y * A _s	* (a - n/2	-71	
Point 4b - f _s = f _y	, Transition from Compressio				р	er ACI 318-05	;	-11	
Point 4b - f _s = f _y	, Transition from Compressio	on controlled section 0.003			p S	er ACI 318-05 ection 9.3.2.2	5 2		
Point 4b - f _s = f _y Concrete strain:	, Transition from Compressio	0.003	to Tension Co		p S Fe	er ACI 318-05 ection 9.3.2.2 or sections in whic	h the net ter	nsile strain at no	
Point 4b - f _s = f _y Concrete strain:	, Transition from Compressio				p S Fr	er ACI 318-05 ection 9.3.2.2 or sections in which rength $\epsilon_{\rm t}$ is between	b the net ter	nsile strain at no	on
Point 4b - f _s = f _y Concrete strain:	, Transition from Compressio	0.003	to Tension Co		p S Fr st	er ACI 318-05 ection 9.3.2.2 or sections in which rength $\epsilon_{\rm t}$ is betweentrolled ans tensions.	h the net ter en the limits on controlle	nsile strain at no for compressic d sections f will	on I be
Point 4b - f _s = f _y Concrete strain:	, Transition from Compressio	0.003	to Tension Co		p S Fr st	er ACI 318-05 ection 9.3.2.2 or sections in which rength $\epsilon_{\rm t}$ is between	h the net ter en the limits on controlle	nsile strain at no for compressic d sections f will	on I be
Point 4b - f _s = f _y Concrete strain:	, Transition from Compressio	0.003	to Tension Co		p S Fr st cc	er ACI 318-05 ection 9.3.2.2 or sections in which rength $\epsilon_{\rm t}$ is betweentrolled ans tensions.	h the net ter en the limits on controlle om that for	nsile strain at no for compressic d sections f will compression co	on I be
Point 4b - f _s = f _y Concrete strain: Bottom reinforc	, Transition from Compressio ement strain (tension):	0.003 $\varepsilon_{\rm t} = {\rm f_y / E_s} =$	to Tension Co		p S Fr st cc	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is betweentrolled ans tensinearly increased from the searly increased from the search search se	h the net ter en the limits on controlle om that for	nsile strain at no for compressic d sections f will compression co	on I be
Point 4b - f _s = f _y Concrete strain: Bottom reinforc c = Top reinforceme	Transition from Compression ement strain (tension): 3.75 in ent strain (compression):	0.003 $\varepsilon_t = f_y / E_s =$ 0.003 *(c-d _c)/o	to Tension Co	ontrolled	p S Fr st co lin	er ACI 318-05 ection 9.3.2.2 or sections in whice rength ε_t is betweentrolled ans tensionary increased from the relation [c	h the net ter en the limits on controlle om that for / (d - c)] = 0	nsile strain at no for compression disections f will compression conductions ℓ ℓ ℓ	on I be ontrolled to 0.9
Point 4b - f _s = f _y Concrete strain: Bottom reinforc c = Top reinforceme	Transition from Compression ement strain (tension): 3.75 in ent strain (compression):	0.003 $\varepsilon_{\rm t} = {\rm f_y / E_s} =$	to Tension Co		p S Fr st co lin	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is betweentrolled ans tensinearly increased from the searly increased from the search search se	h the net ter en the limits on controlle om that for / (d - c)] = 0	nsile strain at no for compression disections f will compression conductions ℓ ℓ ℓ	on I be ontrolled to 0.9
Point 4b - f _s = f _y Concrete strain: Bottom reinforce c = Top reinforcement	Transition from Compression ement strain (tension): 3.75 in ent strain (compression): nent strain:	0.003 $\varepsilon_{t} = f_{y} / E_{s} =$ 0.003 *(c-d _c)/c 0.002	0.0030 0.0010	entrolled	p S Fr st cc lii Fr	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between throlled ans tensinearly increased from the relation [continues of the continues of the relation [continues	h the net ter en the limits on controlle om that for / (d - c)] = 0 ent has n	nsile strain at no for compressic d sections f will compression co .003 / $\epsilon_{\rm t}$ ot reached	on I be ontrolled to 0.9
Point 4b - f _s = f _y Concrete strain: Bottom reinforc c = Top reinforceme	Transition from Compression ement strain (tension): 3.75 in ent strain (compression):	0.003 $\varepsilon_{t} = f_{y} / E_{s} =$ 0.003 *(c-d _c)/c 0.002	0.0030 0.0010	entrolled	p S Fr st cc lii Fr	er ACI 318-05 ection 9.3.2.2 or sections in whice rength ε_t is betweentrolled ans tensionary increased from the relation [c	h the net ter en the limits on controlle om that for / (d - c)] = 0 ent has n	nsile strain at no for compressic d sections f will compression co .003 / $\epsilon_{\rm t}$ ot reached	on I be ontrolled to 0.9
Point 4b - f _s = f _y Concrete strain: Bottom reinforce c = Top reinforcement	ement strain (tension): 3.75 in ent strain (compression): nent strain: 0.73 transition from co	0.003 $\epsilon_t = f_y / E_s =$ $0.003 * (c-d_c)/c$ 0.002 compression controlled	0.0030 0.0010	=>	p S Fr st cc lii Fr	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between throlled ans tensinearly increased from the relation [continues of the continues of the relation [continues	h the net ter en the limits on controlle om that for / (d - c)] = 0 ent has n	nsile strain at no for compressic d sections f will compression co .003 / $\epsilon_{\rm t}$ ot reached	on I be ontrolled to 0.9
Point 4b - f _s = f _y Concrete strain: Bottom reinforce c = Top reinforceme ý = a =	Transition from Compression ement strain (tension): 3.75 in ent strain (compression): nent strain: 0.73 transition from comparts train: 3.15	0.003 $\epsilon_t = f_y / E_s =$ $0.003 * (c-d_c)/c$ 0.002 compression controlled 9 in depth of stress bl	to Tension Co 0.0030 c = 0.0010 to tension cont f equivalent recock	=> crolled sect	p S Fr st cc lii Fr	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between throlled ans tensinearly increased from the relation [continues of the continues of the relation [continues	h the net ter en the limits on controlle om that for / (d - c)] = 0 ent has n	nsile strain at no for compressic d sections f will compression co .003 / $\epsilon_{\rm t}$ ot reached	on I be ontrolled to 0.9
Point 4b - f _s = f _y Concrete strain: Bottom reinforce c = Top reinforceme yield reinforceme ϕ =	ement strain (tension): 3.75 in ent strain (compression): nent strain: 0.73 transition from co	0.003 $\epsilon_t = f_y / E_s =$ $0.003 * (c-d_c)/c$ 0.002 compression controlled 9 in depth of stress bl	to Tension Co 0.0030 = 0.0010 to tension cont	=> crolled sect	p S Fr st cc lii Fr	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between throlled ans tensinearly increased from the relation [continues of the continues of the relation [continues	h the net ter en the limits on controlle om that for / (d - c)] = 0 ent has n	nsile strain at no for compressic d sections f will compression co .003 / $\epsilon_{\rm t}$ ot reached	on I be ontrolled to 0.9
Point 4b - $f_s = f_y$ Concrete strain: Bottom reinforc $c =$ For reinforceme $\phi =$ $a =$ $\phi P_n =$	ement strain (tension): 3.75 in ent strain (compression): nent strain: $0.73 \text{ transition from co}$ $\beta_1 * c = 3.19$ $\phi * [0.85* f_c' * a * b + 1]$	0.003 $\epsilon_t = f_y / E_s =$ $0.003 * (c-d_c)/c$ 0.002 compression controlled 9 in depth of stress bl	to Tension Co 0.0030 c = 0.0010 to tension cont f equivalent recock	=> crolled sect	p S Fr st cc lii Fr	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between throlled ans tensinearly increased from the relation [continuous formula of the relation formula of	h the net ter en the limits on controlle om that for / (d - c)] = 0 ent has n	nsile strain at no for compressic d sections f will compression co .003 / $\epsilon_{\rm t}$ ot reached	on I be ontrolled to 0.9
Point 4b - f _s = f _y Concrete strain: Bottom reinforce c = Top reinforceme ýield reinforceme ф = a =	Transition from Compression ement strain (tension): 3.75 in ent strain (compression): nent strain: 0.73 transition from comparts train: 3.15	0.003 $\epsilon_t = f_y / E_s =$ $0.003 * (c-d_c)/c$ 0.002 compression controlled 9 in depth of stress bl	to Tension Co 0.0030 c = 0.0010 to tension cont f equivalent recock	=> crolled sect	p S Fr st cc lii Fr	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between throlled ans tensinearly increased from the relation [continuous formula of the relation formula of	h the net ter en the limits on controlle om that for / (d - c)] = 0 ent has n	nsile strain at no for compressic d sections f will compression co .003 / $\epsilon_{\rm t}$ ot reached	on I be ontrolled to 0.9
Point 4b - $f_s = f_y$ Concrete strain: Bottom reinforc $c =$ Top reinforceme $\phi =$ $a =$ $\phi P_n =$ $\phi P_n =$	ement strain (tension): 3.75 in ent strain (compression): $0.73 \text{ transition from co}$ $\beta_1 * c = 3.19$ $\phi * [0.85* f_c' * a * b + 78.01 \text{ kips}]$	0.003 $\varepsilon_{t} = f_{y} / E_{s} =$ 0.003 *(c-d _c)/c 0.002 compression controlled 9 in depth of stress bl + 0.001*Es*	0.0030 0.0010 to tension cont f equivalent recock A _{s.b} - f _y * A	=> crolled sect ctangular	p S Fr st ca lin Fr Compression	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between introlled ans tension and the relation [continue of the relation for the relation for the reinforcem section strength reconstruction strength reconstruction in reinforcem.	h the net terenthe limits on controlle om that for // (d - c)] = 0	nsile strain at no for compressio d sections f will compression co .003 / ε _t ot reached	on I be ontrolled to 0.9
Point 4b - $f_s = f_y$ Concrete strain: Bottom reinforc $c =$ Top reinforceme $\phi =$ $a =$ $\phi P_n =$	ement strain (tension): 3.75 in ent strain (compression): $0.73 \text{ transition from co}$ $\beta_1 * c = 3.19$ $\phi * [0.85* f_c' * a * b + 78.01 \text{ kips}]$	0.003 $\epsilon_t = f_y / E_s =$ $0.003 * (c-d_c)/c$ 0.002 compression controlled 9 in depth of stress bl	0.0030 0.0010 to tension cont f equivalent recock A _{s.b} - f _y * A	=> crolled sect ctangular	p S Fr st ca lin Fr Compression	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between introlled ans tension and the relation [continue of the relation for the relation for the reinforcem section strength reconstruction strength reconstruction is the relation for the relation for the relation for the relation for the relation strength reconstruction is the relation for the	h the net terenthe limits on controlle om that for // (d - c)] = 0	nsile strain at no for compressio d sections f will compression co .003 / ε _t ot reached	on I be ontrolled to 0.9
Point 4b - $f_s = f_y$ Concrete strain: Bottom reinforce $C = f_y$ Top reinforcement f_y $f_$	ement strain (tension): 3.75 in ent strain (compression): nent strain: 0.73 transition from co $\beta_1*c = 3.19$ $\phi*[0.85*f_c'*a*b - 78.01 kips]$ $\phi*[(0.85*f_c')]$	0.003 $\varepsilon_{t} = f_{y} / E_{s} =$ 0.003 *(c-d _c)/c 0.002 compression controlled 9 in depth of stress bl + 0.001*Es*	0.0030 0.0010 to tension cont f equivalent recock A _{s.b} - f _y * A	=> crolled sect ctangular	p S Fr st ca lin Fr Compression	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between introlled ans tension and the relation [continue of the relation for the relation for the reinforcem section strength reconstruction strength reconstruction is the relation for the relation for the relation for the relation for the relation strength reconstruction is the relation for the	h the net terenthe limits on controlle om that for // (d - c)] = 0	nsile strain at no for compressio d sections f will compression co .003 / ε _t ot reached	on I be ontrolled to 0.9
Point 4b - $f_s = f_y$ Concrete strain: Bottom reinforc $c =$ Top reinforceme $\phi =$ $a =$ $\phi P_n =$ $\phi P_n =$	ement strain (tension): 3.75 in ent strain (compression): $0.73 \text{ transition from co}$ $\beta_1 * c = 3.19$ $\phi * [0.85* f_c' * a * b + 78.01 \text{ kips}]$	0.003 $\varepsilon_{t} = f_{y} / E_{s} =$ 0.003 *(c-d _c)/c 0.002 compression controlled 9 in depth of stress bl + 0.001*Es*	0.0030 0.0010 to tension cont f equivalent recock A _{s.b} - f _y * A	=> crolled sect ctangular	p S Fr st ca lin Fr Compression	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between introlled ans tension and the relation [continue of the relation for the relation for the reinforcem section strength reconstruction strength reconstruction is the relation for the relation for the relation for the relation for the relation strength reconstruction is the relation for the	h the net terenthe limits on controlle om that for // (d - c)] = 0	nsile strain at no for compressio d sections f will compression co .003 / ε _t ot reached	on I be ontrolled to 0.9
Point 4b - $f_s = f_y$ Concrete strain: Bottom reinforce $c =$ For reinforcement $\phi =$ $a =$ $\phi P_n =$ $\phi P_n =$ $\phi M_n =$	ement strain (tension): 3.75 in ent strain (compression): nent strain: 0.73 transition from co $\beta_1*c = 3.19$ $\phi*[0.85*f_c'*a*b - 78.01 kips]$ $\phi*[(0.85*f_c')]$	0.003 $\varepsilon_{t} = f_{y} / E_{s} =$ 0.003 *(c-d _c)/c 0.002 compression controlled 9 in depth of stress bl + 0.001*Es*	0.0030 0.0010 to tension cont f equivalent recock A _{s.b} - f _y * A	=> crolled sect ctangular	p S Fr st ca lin Fr Compression	er ACI 318-05 ection 9.3.2.2 or sections in which rength ϵ_t is between introlled ans tension and the relation [continue of the relation for the relation for the reinforcem section strength reconstruction strength reconstruction is the relation for the relation for the relation for the relation for the relation strength reconstruction is the relation for the	h the net terenthe limits on controlle om that for // (d - c)] = 0	nsile strain at no for compressio d sections f will compression co .003 / ε _t ot reached	on I be ontrolled to 0.9

	COMPANY NAME	Calculation I CA	No. LCULATION I	NUMBER	₹
	CALCULATION SHEET	Project No.			
	onlinestructuraldesign.com		PROJECT NU	MBER	
Project Title:	Project Name	Calc. By	Date	Rev.	
		Author	today		0
Subject	Reinforced Concrete Column Capacity - Axial Force Bending Moment	Ckd. By	Date		
	Interaction (ACI318)	Checker	today		

Concrete strain:

Section 9.3.2.2

Concrete has reached ultimate concrete design

 $\varepsilon_t = f_y / E_s =$ Bottom reinforcement strain (tension): 0.0040 compressive shortening strain and tension reinforcement

is in transition from tension controlled to tensin controlled

3.23 in From the relation [c / (d - c)] = 0.003 / ϵ_t

Top reinforcement strain (compression):

0.003 *(c-d_c)/c = 0.0007

Yield reinforcement strain: 0.002 Compression reinforcement has not reached yield

0.82 transition from compression controlled to tension controlled section Section strength reduction factor

 $\beta_1 * c =$ 2.74 in depth of equivalent rectangular stress block

 ϕ * [0.85* f_c ' * a * b + 0.0007*Es* $A_{s.b} - f_y * A_s$

42.30 kips $\phi P_n =$

 $\phi * [(0.85* \, f_c{}^{'} * \, a * \, b) * (h/2 \, - \, a/2) \, + \\ \hspace{0.5cm} (\, 0.0007* Es^* \qquad A_{s.b} \,) * (h/2 \, - \, d_c \,) \, + \, f_y * \, A_s * (d \, - \, h/2)]$ $\phi M_n =$

 $\phi M_n =$ 83.95 ft -kips

Point 5 - ε_t = 0.005 - tension controlled section

Concrete strain: 0.003 Concrete has reached ultimate concrete design

compressive shortening strain and et has reached 0.005

Bottom reinforcement strain (tension): ε_{t} = 0.0050 corresponding to $\phi = 0.9$ (tension controlled section)

2.84 in From the relation [c / (d - c)] = 0.003 / ϵ_t

0.003 *(c-d_c)/c = 0.0004Top reinforcement strain (compression):

Yield reinforcement strain: 0.002 Compression reinforcement has not reached yield

0.90 tension controlled section Section strength reduction factor

 $\beta_1 * c =$ 2.41 in depth of equivalent rectangular stress block

φ * [0.85* f_c' * a * b + 0.0004*Es* $A_{s.b} - f_y * A_s$

 $\phi P_n =$ 3.46 kips

 $\phi M_n =$ $\varphi * [(0.85*\,f_c{}'*\,a*\,b)*(h/2\,-\,a/2)\,+ \qquad (\,0.0004*Es* \qquad A_{s.b}\,)*(h/2\,-\,d_c\,)\,+\,f_y{}*\,A_s{}*(d\,-\,h/2)]$

83.52 ft -kips $\phi M_n =$

ACI318-05 - Building code requirements for structural concrete

Calculation No. COMPANY NAME **CALCULATION NUMBER CALCULATION SHEET** Project No. onlinestructuraldesign.com PROJECT NUMBER **Project Name** Project Title: Calc. By Date Author today 0 Subject Reinforced Concrete Column Capacity - Axial Force Bending Moment Ckd. By Date Interaction (ACI318) Checker today

0.0055

Point 6 - Pure Bending

Concrete strain: 0.003

Concrete has reached ultimate concrete design compressive shortening strain and et has reached 0.005

Bottom reinforcement strain (tension): $\varepsilon_t =$

corresponding to φ = 0.9 (tension controlled section)

c = 2.67 in

From the relation [c / (d - c)] = 0.003 / ϵ_t

Top reinforcement strain (compression): $0.003 *(c-d_c)/c = 0.0003$

Yield reinforcement strain: 0.002 => Compression reinforcement has not reached yield

 ϕ = 0.90 tension controlled section Section strength reduction factor

a = $\beta_1 * c$ = 2.27 in depth of equivalent rectangular stress block

 $\phi P_n = \phi^* [0.85 f_c' * a * b + 0.0003 Es^* A_{s.b} - f_v * A_s]$

 $\phi P_n =$ -16.99 kips

 $\phi M_n = \qquad \qquad \phi * \left[(0.85 * f_c ' * a * b) * (h/2 - a/2) + \\ \qquad (0.0003 * Es * A_{s.b}) * (h/2 - d_c) + f_y * A_s * (d - h/2) \right]$

 $\phi M_n = 79.09 \text{ ft -kips}$

Point 7 - Maximum tension

 ϕ = 0.90 tension controlled section

Section strength reduction factor

$$\phi P_n = - \phi * f_v * [A_{s,b} + A_s]$$

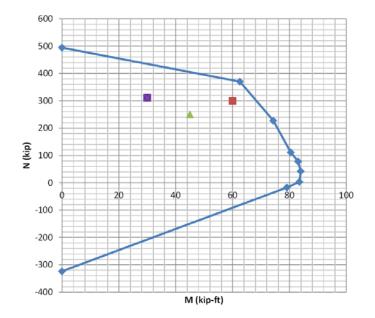
 $\phi P_n = -324.00 \text{ kips}$

 $\phi M_n = 0.00 \text{ ft -kips}$

Data for the M-N interaction graph:

	N _{cap}	IVI _{cap}
Point 1	494.83	0.00
Point 2	370.52	62.58
Point 3	227.60	74.32
Point 4	111.42	80.48
Point 4b	78.01	83.05
Point 4c	42.30	83.95
Point 5	3.46	83.52
Point 6	-16.99	79.09
Point 7	-324.00	0.00

	N_{eff}	M_{eff}
CO1	300.0	60
CO2	250.0	45
CO3	311.0	30



References:

ACI318-05 - Building code requirements for structural concrete