

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

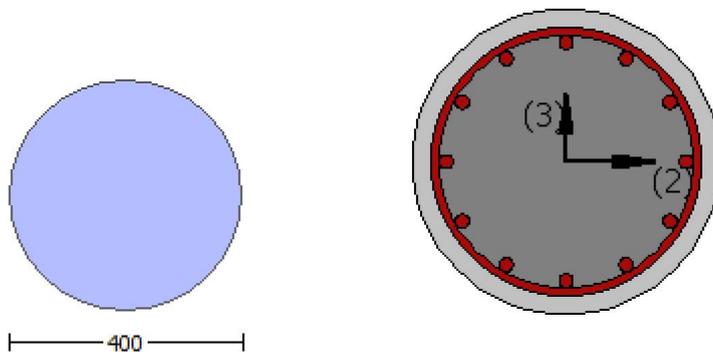
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

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Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 28.00$

New material: Steel Strength, $f_s = f_{sm} = 420.00$

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Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3765E+007$

Shear Force, $V_a = -4586.336$

EDGE -B-

Bending Moment, $M_b = 0.04476539$

Shear Force, $V_b = 4586.336$

BOTH EDGES

Axial Force, $F = -4769.398$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 1272.345$

-Compression: $A_{sc} = 1781.283$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sc,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 214387.932$

V_n ((10.3), ASCE 41-17) = $k_n l \cdot V_{CoIO} = 214387.932$

$V_{CoI} = 214387.932$

$k_n l = 1.00$

displacement_ductility_demand = 0.01738074

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f' \cdot V_f$ ' where V_f is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)

$f'_c = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 1.3765E+007$

$V_u = 4586.336$

$d = 0.8 \cdot D = 320.00$

$N_u = 4769.398$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 157913.67$

$A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$

$f_y = 400.00$

$s = 100.00$

V_s is multiplied by $CoI = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 238930.50$

$$b_w*d = *d*d/4 = 80424.772$$

displacement_ductility_demand is calculated as ϕ / y

- Calculation of ϕ / y for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation $\theta = 0.00039905$
 $y = (M_y * L_s / 3) / E_{eff} = 0.02295905$ ((4.29), Biskinis Phd)
 $M_y = 2.1517E+008$
 $L_s = M/V$ (with $L_s > 0.1*L$ and $L_s < 2*L$) = 3001.241
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 9.3758E+012$
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
 $E_c * I_g = 3.1253E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.1517E+008$
 ϕ ((10a) or (10b)) = 1.1483164E-005
 M_{y_ten} (8a) = 2.1517E+008
 ϕ_{ten} (7a) = 72.79824
error of function (7a) = 0.00155286
 M_{y_com} (8b) = 4.0201E+008
 ϕ_{com} (7b) = 69.01016
error of function (7b) = -0.00040881
with $e_y = 0.0021$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
= 0.3645
with fc = 28.00

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

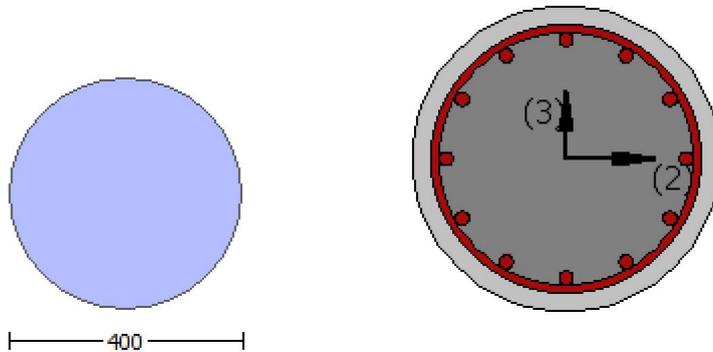
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.32561

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, min} \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.7372036E-031$

EDGE -B-

Shear Force, $V_b = 3.7372036E-031$

BOTH EDGES

Axial Force, $F = -4771.233$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{s,ten} = 1017.876$

-Compression: $A_{s,com} = 1017.876$

-Middle: $A_{s,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

$\phi = 1.0472$

$\lambda = 0.92729522$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot \lambda = 37.11712$

conf. factor $\lambda = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$\phi \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

$\phi = 1.0472$

$\lambda = 0.92729522$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$\mu = 2.2910E+008$

$= 1.0472$

$' = 0.92729522$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$\mu = 2.2910E+008$

$= 1.0472$

$' = 0.92729522$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$$N = 4771.233$$

$$A_c = 125663.706$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l \cdot V_{Col0}$

$V_{Col0} = 299278.805$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 28.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.0979367E-011$

$\nu_u = 3.7372036E-031$

$d = 0.8 \cdot D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w \cdot d = \sqrt{d} \cdot d/4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l \cdot V_{Col0}$

$V_{Col0} = 299278.805$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 28.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.0979367E-011$

$\nu_u = 3.7372036E-031$

$d = 0.8 \cdot D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w \cdot d = \sqrt{d} \cdot d/4 = 80424.772$

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
Concrete Elasticity, $E_c = 24870.062$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$

Diameter, $D = 400.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.32561
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou, min} > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -9.8626872E-031$
EDGE -B-
Shear Force, $V_b = 9.8626872E-031$
BOTH EDGES
Axial Force, $F = -4771.233$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st, ten} = 1017.876$
-Compression: $A_{sc, com} = 1017.876$
-Middle: $A_{sc, mid} = 1017.876$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.51034251$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$
with
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 2.2910E+008$
 $M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment

direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910\text{E}+008$$

$M_{u2+} = 2.2910\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$$M_u = 2.2910\text{E}+008$$

$$= 1.0472$$

$$\lambda = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$$f_c = 28.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$$l_b/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$A_c = 125663.706$$

$$= \lambda \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$$M_u = 2.2910\text{E}+008$$

$$= 1.0472$$

$$\lambda = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$$f_c = 28.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$$l_b/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$A_c = 125663.706$$

$$= \lambda \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: fcc = fc* c = 37.11712
conf. factor c = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 525.00
lb/d = 1.00
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: fcc = fc* c = 37.11712
conf. factor c = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 525.00
lb/d = 1.00
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 9.9556147E-012$
 $V_u = 9.8626872E-031$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4771.233$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 165809.354$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 420.00$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 282706.38$
 $b_w \cdot d = \frac{A_v \cdot f_y \cdot d}{4} = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n I \cdot V_{Col0}$
 $V_{Col0} = 299278.805$
 $k_n I = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 9.9556147E-012$
 $V_u = 9.8626872E-031$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4771.233$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 165809.354$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 420.00$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 282706.38$
 $b_w \cdot d = \frac{A_v \cdot f_y \cdot d}{4} = 80424.772$

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
 At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
 At local axis: 2

Integration Section: (a)
 Section Type: rccs

Constant Properties

Knowledge Factor, $\phi = 1.00$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$
Diameter, $D = 400.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d >= 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.6986061E-011$
Shear Force, $V_2 = -4586.336$
Shear Force, $V_3 = 8.2104443E-015$
Axial Force, $F = -4769.398$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 1272.345$
-Compression: $A_{sc} = 1781.283$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1017.876$
-Compression: $A_{sc,com} = 1017.876$
-Middle: $A_{st,mid} = 1017.876$
Mean Diameter of Tension Reinforcement, $D_bL = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = 1.0^*$ $u = 0.01647478$
 $u = y + p = 0.01647478$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01147478$ ((4.29), Biskinis Phd)
 $M_y = 2.1517E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 9.3758E+012$
factor = 0.30
 $A_g = 125663.706$
 $f_c' = 28.00$
 $N = 4769.398$
 $E_c * I_g = 3.1253E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.1517E+008$
 y ((10a) or (10b)) = $1.1483164E-005$
 M_{y_ten} (8a) = $2.1517E+008$
 $_{ten}$ (7a) = 72.79824
error of function (7a) = 0.00155286
 M_{y_com} (8b) = $4.0201E+008$
 $_{com}$ (7b) = 69.01016
error of function (7b) = -0.00040881
with $e_y = 0.0021$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00135549$

$N = 4769.398$
 $A_c = 125663.706$
 $= 0.3645$
with $f_c = 28.00$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

- Calculation of ρ -

From table 10-9: $\rho = 0.005$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$
shear control ratio $V_y E / V_{ColOE} = 0.51034251$

$d = 0.00$

$s = 0.00$

$t = 2 \cdot A_v / (d_c \cdot s) + 4 \cdot t_f / D \cdot (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, is the area of the circular stirrup

$d_c = D - 2 \cdot \text{cover} - \text{Hoop Diameter} = 340.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$N_{UD} = 4769.398$

$A_g = 125663.706$

$f_{cE} = 28.00$

$f_{ytE} = f_{ylE} = 420.00$

$\rho_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0243$

$f_{cE} = 28.00$

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

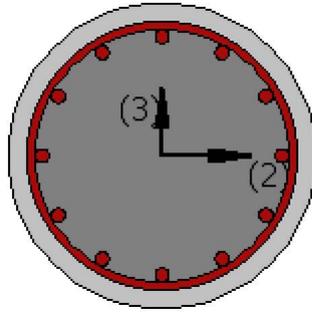
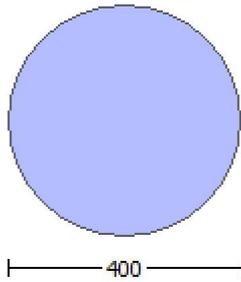
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 28.00$

New material: Steel Strength, $f_s = f_{sm} = 420.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.6986061E-011$

Shear Force, $V_a = 8.2104443E-015$

EDGE -B-

Bending Moment, $M_b = -7.7176173E-012$

Shear Force, $V_b = -8.2104443E-015$

BOTH EDGES

Axial Force, $F = -4769.398$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 1272.345$

-Compression: $A_{sc} = 1781.283$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{st,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 270862.194$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 270862.194$
 $V_{CoI} = 270862.194$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.6986061E-011$
 $V_u = 8.2104443E-015$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4769.398$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 157913.67$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $CoI = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 238930.50$
 $b_w \cdot d = \sqrt{2} \cdot d^2 / 4 = 80424.772$

 $displacement_ductility_demand$ is calculated as ϕ / y

- Calculation of ϕ / y for END A -
for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\phi = 5.0574879E-021$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.01147478$ ((4.29), Biskinis Phd))
 $M_y = 2.1517E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 9.3758E+012$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 28.00$
 $N = 4769.398$
 $E_c \cdot I_g = 3.1253E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ / y and M_y according to (7) - (8) in Biskinis and Fardis

 $M_y = \min(M_{y_ten}, M_{y_com}) = 2.1517E+008$
 y ((10a) or (10b)) = 1.1483164E-005
 M_{y_ten} (8a) = 2.1517E+008
 y_{ten} (7a) = 72.79824
error of function (7a) = 0.00155286
 M_{y_com} (8b) = 4.0201E+008
 y_{com} (7b) = 69.01016
error of function (7b) = -0.00040881
with $e_y = 0.0021$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d_1 = 44.00$

R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
= 0.3645

with $f_c = 28.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 4

column C1, Floor 1

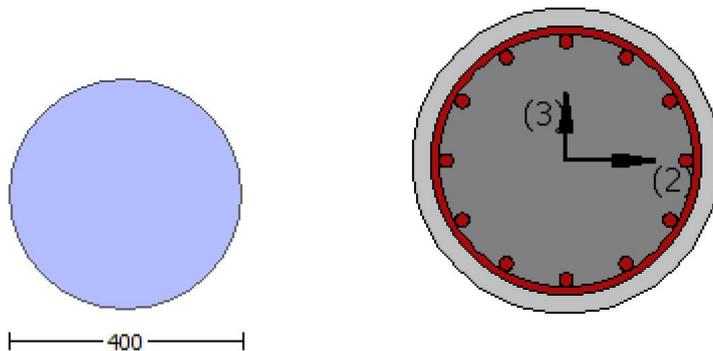
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.32561

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.7372036E-031$

EDGE -B-

Shear Force, $V_b = 3.7372036E-031$

BOTH EDGES

Axial Force, $F = -4771.233$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st, \text{ten}} = 1017.876$

-Compression: $A_{sc, \text{com}} = 1017.876$

-Middle: $A_{sc, \text{mid}} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c * c = 37.11712$

conf. factor $c = 1.32561$

fc = 28.00

From 10.3.5, ASCE41-17, Final value of fy: $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

lb/d = 1.00

d1 = 44.00

R = 200.00

v = 0.00135568

N = 4771.233

Ac = 125663.706

= $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor c = 1.32561

fc = 28.00

From 10.3.5, ASCE41-17, Final value of fy: $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

lb/d = 1.00

d1 = 44.00

R = 200.00

v = 0.00135568

N = 4771.233

Ac = 125663.706

= $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor c = 1.32561

fc = 28.00

From 10.3.5, ASCE41-17, Final value of fy: $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

lb/d = 1.00

d1 = 44.00

R = 200.00

v = 0.00135568

N = 4771.233

Ac = 125663.706

= $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_2

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.2910E+008$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

$$\text{conf. factor } c = 1.32561$$

$$f_c = 28.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$$l_b/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{Col0}$

$$V_{Col0} = 299278.805$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 28.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$\mu = 1.0979367E-011$$

$$V_u = 3.7372036E-031$$

$$d = 0.8 \cdot D = 320.00$$

$$N_u = 4771.233$$

$$A_g = 125663.706$$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$$A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 123370.055$$

$$f_y = 420.00$$

$$s = 100.00$$

V_s is multiplied by $\text{Col} = 0.00$

$$s/d = 0.3125$$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$$b_w \cdot d = \cdot d \cdot d/4 = 80424.772$$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 299278.805$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1.0979367E-011$

$\nu_u = 3.7372036E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \lambda / 2 * A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w * d = \lambda * d * d / 4 = 80424.772$

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rccs

Constant Properties

Knowledge Factor, $\lambda = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths, the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.32561

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o / l_{ou, min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -9.8626872E-031$

EDGE -B-

Shear Force, $V_b = 9.8626872E-031$

BOTH EDGES

Axial Force, $F = -4771.233$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sc,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

$\lambda = 1.0472$

$\lambda' = 0.92729522$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c^* c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: fcc = fc* c = 37.11712
conf. factor c = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 525.00
lb/d = 1.00
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: fcc = fc* c = 37.11712
conf. factor c = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 525.00
lb/d = 1.00
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: fcc = fc* c = 37.11712
conf. factor c = 1.32561
fc = 28.00

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$$l_b/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$A_c = 125663.706$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$$V_{\text{Col}0} = 299278.805$$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 9.9556147E-012$$

$$V_u = 9.8626872E-031$$

$$d = 0.8 \cdot D = 320.00$$

$$N_u = 4771.233$$

$$A_g = 125663.706$$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$$A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 123370.055$$

$$f_y = 420.00$$

$$s = 100.00$$

V_s is multiplied by $\text{Col} = 0.00$

$$s/d = 0.3125$$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$$b_w \cdot d = \text{Min}(d, 4) = 80424.772$$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$$V_{\text{Col}0} = 299278.805$$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 9.9556147E-012$$

$$V_u = 9.8626872E-031$$

$$d = 0.8 \cdot D = 320.00$$

$$N_u = 4771.233$$

$$A_g = 125663.706$$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$$A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 123370.055$$

$$f_y = 420.00$$

$$s = 100.00$$

V_s is multiplied by $\text{Col} = 0.00$

$$s/d = 0.3125$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 282706.38$$

$$b_w * d = *d*d/4 = 80424.772$$

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3

Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, $\phi = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d \geq 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.3765E+007$

Shear Force, $V_2 = -4586.336$

Shear Force, $V_3 = 8.2104443E-015$

Axial Force, $F = -4769.398$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 1272.345$

-Compression: $A_{sc} = 1781.283$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{st,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $DbL = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^* u = 0.02795905$

$$u = y + p = 0.02795905$$

- Calculation of y -

$$y = (M_y * L_s / 3) / E_{eff} = 0.02295905 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 2.1517E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 3001.241$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 9.3758E+012$$

factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+013

Calculation of Yielding Moment My

Calculation of ρ_y and My according to (7) - (8) in Biskinis and Fardis

My = Min(My_ten, My_com) = 2.1517E+008
 ρ_y ((10a) or (10b)) = 1.1483164E-005
My_ten (8a) = 2.1517E+008
 ρ_{y_ten} (7a) = 72.79824
error of function (7a) = 0.00155286
My_com (8b) = 4.0201E+008
 ρ_{y_com} (7b) = 69.01016
error of function (7b) = -0.00040881
with e_y = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
= 0.3645
with fc = 28.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of ρ_p -

From table 10-9: ρ_p = 0.005

with:

- Columns controlled by inadequate development or splicing along the clear height because lb/d < 1

shear control ratio $V_y E / V_{CoI} E = 0.51034251$

d = 0.00

s = 0.00

$t = 2 * A_v / (d_c * s) + 4 * t_f / D * (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, is the area of the circular stirrup

$d_c = D - 2 * cover - Hoop Diameter = 340.00$

The term $2 * t_f / bw * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / bw$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

NUD = 4769.398

Ag = 125663.706

f'cE = 28.00

fytE = fyIE = 420.00

$\rho_l = Area_Tot_Long_Rein / (Ag) = 0.0243$

f'cE = 28.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

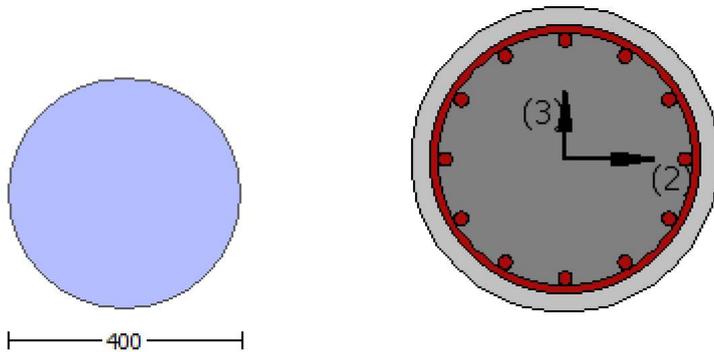
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 28.00$

New material: Steel Strength, $f_s = f_{sm} = 420.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3765E+007$

Shear Force, $V_a = -4586.336$

EDGE -B-

Bending Moment, $M_b = 0.04476539$

Shear Force, $V_b = 4586.336$

BOTH EDGES

Axial Force, $F = -4769.398$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{s,ten} = 1017.876$

-Compression: $A_{s,com} = 1017.876$

-Middle: $A_{s,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 270862.194$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 270862.194$

$V_{CoI} = 270862.194$

$k_n = 1.00$

displacement_ductility_demand = 0.09594703

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 0.04476539$

$V_u = 4586.336$

$d = 0.8 \cdot D = 320.00$

$N_u = 4769.398$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 157913.67$

$A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$

$f_y = 400.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 238930.50$

$b_w \cdot d = \sqrt{N_u} \cdot d / 4 = 80424.772$

displacement_ductility_demand is calculated as ϕ / y

- Calculation of ϕ / y for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 0.00022019

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00229496$ ((4.29), Biskinis Phd)

$M_y = 2.1517E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 9.3758E+012$

factor = 0.30

$A_g = 125663.706$

$f_c' = 28.00$

$N = 4769.398$

$$E_c \cdot I_g = 3.1253E+013$$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to (7) - (8) in Biskinis and Fardis

$$M_y = \min(M_{y_ten}, M_{y_com}) = 2.1517E+008$$

$$\rho_y ((10a) \text{ or } (10b)) = 1.1483164E-005$$

$$M_{y_ten} (8a) = 2.1517E+008$$

$$\rho_{y_ten} (7a) = 72.79824$$

$$\text{error of function (7a)} = 0.00155286$$

$$M_{y_com} (8b) = 4.0201E+008$$

$$\rho_{y_com} (7b) = 69.01016$$

$$\text{error of function (7b)} = -0.00040881$$

$$\text{with } e_y = 0.0021$$

$$e_{co} = 0.002$$

$$a_{pl} = 0.35 ((9a) \text{ in Biskinis and Fardis for no FRP Wrap})$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135549$$

$$N = 4769.398$$

$$A_c = 125663.706$$

$$= 0.3645$$

$$\text{with } f_c = 28.00$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

End Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 6

column C1, Floor 1

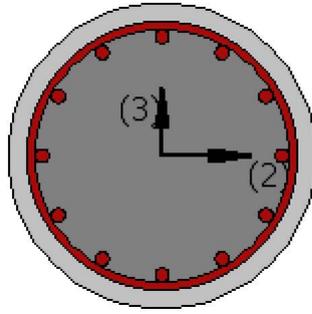
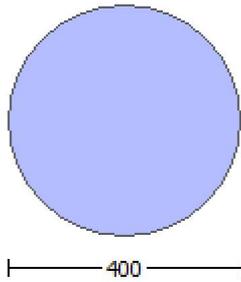
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rccs

Constant Properties

 Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 24870.062$
 Steel Elasticity, $E_s = 200000.00$

 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$

 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.32561
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou, min} >= 1$)
 No FRP Wrapping

 Stepwise Properties

 At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -3.7372036E-031$
 EDGE -B-
 Shear Force, $V_b = 3.7372036E-031$
 BOTH EDGES
 Axial Force, $F = -4771.233$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 3053.628$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st, ten} = 1017.876$
 -Compression: $A_{sc, com} = 1017.876$
 -Middle: $A_{sc, mid} = 1017.876$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 2.2910E+008$
 $M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 2.2910E+008$
 $M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.2910E+008$

$\phi = 1.0472$
 $\lambda = 0.92729522$
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$
conf. factor $c = 1.32561$
 $f_c = 28.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$
 $l_b/d = 1.00$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00135568$
 $N = 4771.233$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.2910E+008$

$\phi = 1.0472$
 $\lambda = 0.92729522$
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$
conf. factor $c = 1.32561$
 $f_c = 28.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$
 $l_b/d = 1.00$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00135568$
 $N = 4771.233$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.2910E+008$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 525.00$

$$lb/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$Ac = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.3645$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.2910E+008$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 525.00$

$$lb/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$Ac = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.3645$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, Vr1 = 299278.805

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO

VColO = 299278.805

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

fc' = 28.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.0979367E-011

Vu = 3.7372036E-031

d = 0.8*D = 320.00

Nu = 4771.233

Ag = 125663.706

From (11.5.4.8), ACI 318-14: Vs = 165809.354

Av = /2*A_stirrup = 123370.055

fy = 420.00

s = 100.00

Vs is multiplied by Col = 0.00

s/d = 0.3125

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 282706.38

bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VColO

VColO = 299278.805

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

fc' = 28.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.0979367E-011

Vu = 3.7372036E-031

d = 0.8*D = 320.00

Nu = 4771.233

Ag = 125663.706

From (11.5.4.8), ACI 318-14: Vs = 165809.354

Av = /2*A_stirrup = 123370.055

fy = 420.00

s = 100.00

Vs is multiplied by Col = 0.00

s/d = 0.3125

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 282706.38

bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rccs

Constant Properties

Knowledge Factor, $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.32561

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -9.8626872E-031$

EDGE -B-

Shear Force, $V_b = 9.8626872E-031$

BOTH EDGES

Axial Force, $F = -4771.233$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sc,com} = 1017.876$

-Middle: $A_{sc,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$$\mu = 2.2910E+008$$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$$\mu = 2.2910E+008$$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_2 +

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$$\mu = 2.2910E+008$$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

lb/d = 1.00
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: fcc = fc* c = 37.11712

conf. factor c = 1.32561

fc = 28.00

From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 525.00

lb/d = 1.00

d1 = 44.00

R = 200.00

v = 0.00135568

N = 4771.233

Ac = 125663.706

= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 299278.805

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

fc' = 28.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 9.9556147E-012

Vu = 9.8626872E-031

d = 0.8*D = 320.00

Nu = 4771.233

Ag = 125663.706

From (11.5.4.8), ACI 318-14: Vs = 165809.354

Av = /2*A_stirup = 123370.055

fy = 420.00

s = 100.00

Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*VF'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.9556147E-012
Vu = 9.8626872E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = /2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/d >= 1)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -7.7176173E-012$
Shear Force, $V2 = 4586.336$
Shear Force, $V3 = -8.2104443E-015$
Axial Force, $F = -4769.398$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten} = 1017.876$
-Compression: $A_{s,com} = 1017.876$
-Middle: $A_{s,mid} = 1017.876$
Mean Diameter of Tension Reinforcement, $DbL = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.01647478$
 $u = y + p = 0.01647478$

- Calculation of y -

$y = (M \cdot L_s / 3) / E_{eff} = 0.01147478$ ((4.29), Biskinis Phd))
 $M_y = 2.1517E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 9.3758E+012$
factor = 0.30
 $A_g = 125663.706$
 $f_c' = 28.00$
 $N = 4769.398$
 $E_c \cdot I_g = 3.1253E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \text{Min}(M_{y,ten}, M_{y,com}) = 2.1517E+008$
 y ((10a) or (10b)) = 1.1483164E-005
 $M_{y,ten}$ (8a) = 2.1517E+008
 y_{ten} (7a) = 72.79824
error of function (7a) = 0.00155286
 $M_{y,com}$ (8b) = 4.0201E+008
 y_{com} (7b) = 69.01016
error of function (7b) = -0.00040881
with $e_y = 0.0021$
 $e_{co} = 0.002$
 $a_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d1 = 44.00$
 $R = 200.00$
 $v = 0.00135549$
 $N = 4769.398$
 $A_c = 125663.706$
= 0.3645
with $f_c = 28.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of p -

From table 10-9: $p = 0.005$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{CoI} E = 0.51034251$

$d = 0.00$

$s = 0.00$

$t = 2 \cdot A_v / (d_c \cdot s) + 4 \cdot t_f / D \cdot (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, is the area of the circular stirrup

$d_c = D - 2 \cdot \text{cover} - \text{Hoop Diameter} = 340.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$NUD = 4769.398$

$Ag = 125663.706$

$f_{cE} = 28.00$

$f_{yE} = f_{yI} = 420.00$

$p_l = \text{Area_Tot_Long_Rein} / (Ag) = 0.0243$

$f_{cE} = 28.00$

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 7

column C1, Floor 1

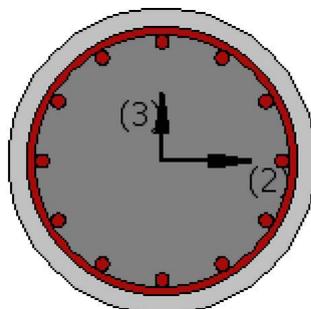
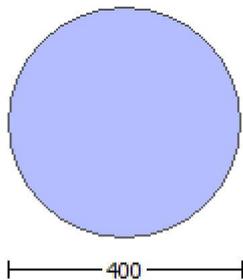
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 28.00$

New material: Steel Strength, $f_s = f_{sm} = 420.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.6986061E-011$

Shear Force, $V_a = 8.2104443E-015$

EDGE -B-

Bending Moment, $M_b = -7.7176173E-012$

Shear Force, $V_b = -8.2104443E-015$

BOTH EDGES

Axial Force, $F = -4769.398$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sl,com} = 1017.876$

-Middle: $A_{sl,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 * V_n = 270862.194$

V_n ((10.3), ASCE 41-17) = $k_n l * V_{CoI} = 270862.194$

$V_{CoI} = 270862.194$

$k_n l = 1.00$

$displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\gamma = 1$ (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 7.7176173E-012$

$V_u = 8.2104443E-015$

$d = 0.8 * D = 320.00$

$N_u = 4769.398$

Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = /2*A_stirup = 123370.055
fy = 400.00
s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = *d*d/4 = 80424.772

displacement_ductility_demand is calculated as / y

- Calculation of / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation = 3.9748299E-022
y = (My*Ls/3)/Eleff = 0.01147478 ((4.29),Biskinis Phd)
My = 2.1517E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 9.3758E+012
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4769.398
Ec*Ig = 3.1253E+013

Calculation of Yielding Moment My

Calculation of y and My according to (7) - (8) in Biskinis and Fardis

My = Min(My_ten,My_com) = 2.1517E+008
y ((10a) or (10b)) = 1.1483164E-005
My_ten (8a) = 2.1517E+008
_ten (7a) = 72.79824
error of function (7a) = 0.00155286
My_com (8b) = 4.0201E+008
_com (7b) = 69.01016
error of function (7b) = -0.00040881
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135549
N = 4769.398
Ac = 125663.706
= 0.3645
with fc = 28.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

End Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 8

column C1, Floor 1

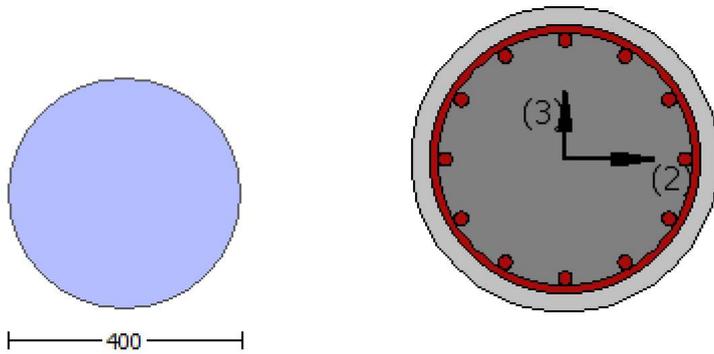
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.32561

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.7372036E-031$

EDGE -B-

Shear Force, $V_b = 3.7372036E-031$

BOTH EDGES

Axial Force, $F = -4771.233$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sc,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

$\phi = 1.0472$

$\phi' = 0.92729522$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$\phi' * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$Ac = 125663.706$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$Ac = 125663.706$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l * V_{Col0}$

$V_{Col0} = 299278.805$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d/s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.0979367E-011$

$\nu_u = 3.7372036E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \sqrt{2} * A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w * d = * d * d/4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l * V_{Col0}$

$V_{Col0} = 299278.805$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d/s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.0979367E-011$

$\nu_u = 3.7372036E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \sqrt{2} * A_{stirrup} = 123370.055$

$f_y = 420.00$

s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 525.00

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lo_u,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -9.8626872E-031
EDGE -B-
Shear Force, Vb = 9.8626872E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.51034251

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 525.00$

$lb/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$Ac = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 525.00$

$lb/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$Ac = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 299278.805$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.9556147E-012$

$\nu_u = 9.8626872E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \lambda / 2 * A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w * d = \lambda * d * d / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 299278.805$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.9556147E-012$

$\nu_u = 9.8626872E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \lambda / 2 * A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w * d = \lambda * d * d / 4 = 80424.772$

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\phi = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 0.04476539$

Shear Force, $V_2 = 4586.336$

Shear Force, $V_3 = -8.2104443E-015$

Axial Force, $F = -4769.398$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1017.876$

-Compression: $A_{sl,com} = 1017.876$

-Middle: $A_{sl,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $DbL = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.00729496$

$u = y + p = 0.00729496$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00229496$ ((4.29), Biskinis Phd))

$M_y = 2.1517E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 9.3758E+012$

factor = 0.30

$A_g = 125663.706$

$f_c' = 28.00$

$N = 4769.398$

$E_c * I_g = 3.1253E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.1517E+008$

y ((10a) or (10b)) = $1.1483164E-005$

M_{y_ten} (8a) = $2.1517E+008$

y_{ten} (7a) = 72.79824

error of function (7a) = 0.00155286

M_{y_com} (8b) = $4.0201E+008$

y_{com} (7b) = 69.01016

error of function (7b) = -0.00040881

with $\epsilon_y = 0.0021$

$\epsilon_{co} = 0.002$

$\alpha_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135549$

$N = 4769.398$

$A_c = 125663.706$

$= 0.3645$

with $f_c = 28.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of ρ -

From table 10-9: $\rho = 0.005$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/d < 1$

shear control ratio $V_y E / C_o I_{OE} = 0.51034251$

$d = 0.00$

$s = 0.00$

$t = 2 \cdot A_v / (d_c \cdot s) + 4 \cdot t_f / D \cdot (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, is the area of the circular stirrup

$d_c = D - 2 \cdot \text{cover} - \text{Hoop Diameter} = 340.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$N_{UD} = 4769.398$

$A_g = 125663.706$

$f_{cE} = 28.00$

$f_{yE} = f_{yIE} = 420.00$

$\rho_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0243$

$f_{cE} = 28.00$

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

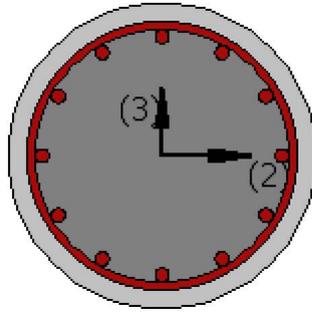
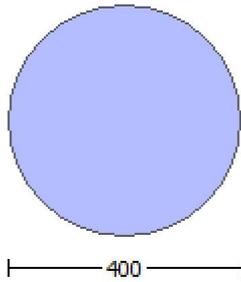
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 28.00$

New material: Steel Strength, $f_s = f_{sm} = 420.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -8.6921E+006$

Shear Force, $V_a = -2896.171$

EDGE -B-

Bending Moment, $M_b = 0.02826837$

Shear Force, $V_b = 2896.171$

BOTH EDGES

Axial Force, $F = -4770.074$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 1272.345$

-Compression: $A_{sc} = 1781.283$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1017.876$

-Compression: $A_{sl,com} = 1017.876$

-Middle: $A_{sl,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 214387.999$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 214387.999$
 $V_{CoI} = 214387.999$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.01097555$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 8.6921E+006$
 $V_u = 2896.171$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4770.074$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 157913.67$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $CoI = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 238930.50$
 $b_w \cdot d = \mu_u \cdot d / 4 = 80424.772$

 $displacement_ductility_demand$ is calculated as δ / y

- Calculation of δ / y for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation = 0.00025199
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.02295907$ ((4.29), Biskinis Phd))
 $M_y = 2.1517E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3001.241
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 9.3758E+012$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 28.00$
 $N = 4770.074$
 $E_c \cdot I_g = 3.1253E+013$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to (7) - (8) in Biskinis and Fardis

 $M_y = \min(M_{y_ten}, M_{y_com}) = 2.1517E+008$
 y ((10a) or (10b)) = 1.1483167E-005
 M_{y_ten} (8a) = 2.1517E+008
 δ_{ten} (7a) = 72.79826
error of function (7a) = 0.00155288
 M_{y_com} (8b) = 4.0201E+008
 δ_{com} (7b) = 69.01017
error of function (7b) = -0.00040881
with $e_y = 0.0021$
 $e_{co} = 0.002$
 $apl = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d1 = 44.00$

R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
= 0.3645

with $f_c = 28.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

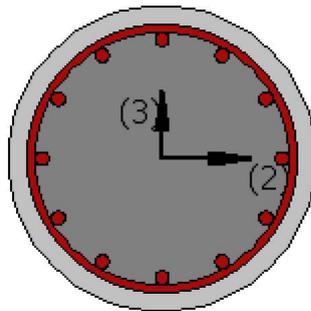
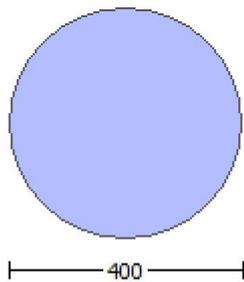
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.32561

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.7372036E-031$

EDGE -B-

Shear Force, $V_b = 3.7372036E-031$

BOTH EDGES

Axial Force, $F = -4771.233$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st, \text{ten}} = 1017.876$

-Compression: $A_{st, \text{com}} = 1017.876$

-Middle: $A_{st, \text{mid}} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c * c = 37.11712$

conf. factor $c = 1.32561$

fc = 28.00

From 10.3.5, ASCE41-17, Final value of fy: $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

lb/d = 1.00

d1 = 44.00

R = 200.00

v = 0.00135568

N = 4771.233

Ac = 125663.706

= $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor c = 1.32561

fc = 28.00

From 10.3.5, ASCE41-17, Final value of fy: $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

lb/d = 1.00

d1 = 44.00

R = 200.00

v = 0.00135568

N = 4771.233

Ac = 125663.706

= $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor c = 1.32561

fc = 28.00

From 10.3.5, ASCE41-17, Final value of fy: $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

lb/d = 1.00

d1 = 44.00

R = 200.00

v = 0.00135568

N = 4771.233

Ac = 125663.706

= $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_2

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.2910E+008$

$$= 1.0472$$

$$\mu = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$$l_b/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$A_c = 125663.706$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{Col0}$

$V_{Col0} = 299278.805$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\mu = 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$$\mu = 1.0979367E-011$$

$$V_u = 3.7372036E-031$$

$$d = 0.8 \cdot D = 320.00$$

$$N_u = 4771.233$$

$$A_g = 125663.706$$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$$A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$$

$$f_y = 420.00$$

$$s = 100.00$$

V_s is multiplied by $Col = 0.00$

$$s/d = 0.3125$$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$$b_w \cdot d = \frac{V_u}{f_y} = 80424.772$$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 299278.805$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1.0979367E-011$

$V_u = 3.7372036E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \lambda / 2 * A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w * d = \lambda * d * d / 4 = 80424.772$

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rccs

Constant Properties

Knowledge Factor, $\lambda = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths, the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.32561

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o / l_{ou, min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -9.8626872E-031$

EDGE -B-

Shear Force, $V_b = 9.8626872E-031$

BOTH EDGES

Axial Force, $F = -4771.233$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sc,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

$\phi = 1.0472$

$\phi' = 0.92729522$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$\phi' = \phi \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: fcc = fc* c = 37.11712
conf. factor c = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 525.00
lb/d = 1.00
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: fcc = fc* c = 37.11712
conf. factor c = 1.32561
fc = 28.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 525.00
lb/d = 1.00
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: fcc = fc* c = 37.11712
conf. factor c = 1.32561
fc = 28.00

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$$l_b/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$A_c = 125663.706$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$$V_{\text{Col}0} = 299278.805$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f_c' = 28.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$\mu_u = 9.9556147\text{E-}012$$

$$V_u = 9.8626872\text{E-}031$$

$$d = 0.8 \cdot D = 320.00$$

$$N_u = 4771.233$$

$$A_g = 125663.706$$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$$A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 123370.055$$

$$f_y = 420.00$$

$$s = 100.00$$

V_s is multiplied by $\text{Col} = 0.00$

$$s/d = 0.3125$$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$$b_w \cdot d = \text{Min}(d, 4) = 80424.772$$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$$V_{\text{Col}0} = 299278.805$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f_c' = 28.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$\mu_u = 9.9556147\text{E-}012$$

$$V_u = 9.8626872\text{E-}031$$

$$d = 0.8 \cdot D = 320.00$$

$$N_u = 4771.233$$

$$A_g = 125663.706$$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$$A_v = \sqrt{2} \cdot A_{\text{stirrup}} = 123370.055$$

$$f_y = 420.00$$

$$s = 100.00$$

V_s is multiplied by $\text{Col} = 0.00$

$$s/d = 0.3125$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 282706.38$$

$$b_w * d = *d*d/4 = 80424.772$$

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

$$\text{Knowledge Factor, } = 1.00$$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

$$\text{New material of Primary Member: Concrete Strength, } f_c = f_{cm} = 28.00$$

$$\text{New material of Primary Member: Steel Strength, } f_s = f_{sm} = 420.00$$

$$\text{Concrete Elasticity, } E_c = 24870.062$$

$$\text{Steel Elasticity, } E_s = 200000.00$$

$$\text{Diameter, } D = 400.00$$

$$\text{Cover Thickness, } c = 25.00$$

$$\text{Element Length, } L = 3000.00$$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d \geq 1$)

No FRP Wrapping

Stepwise Properties

$$\text{Bending Moment, } M = -6.6801918E-012$$

$$\text{Shear Force, } V_2 = -2896.171$$

$$\text{Shear Force, } V_3 = 5.1847167E-015$$

$$\text{Axial Force, } F = -4770.074$$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

$$\text{-Tension: } A_{s,t} = 1272.345$$

$$\text{-Compression: } A_{s,c} = 1781.283$$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

$$\text{-Tension: } A_{s,ten} = 1017.876$$

$$\text{-Compression: } A_{s,com} = 1017.876$$

$$\text{-Middle: } A_{s,mid} = 1017.876$$

$$\text{Mean Diameter of Tension Reinforcement, } D_bL = 18.00$$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = 1.0^* u = 0.07134961$

$$u = y + p = 0.07134961$$

- Calculation of y -

$$y = (M_y * L_s / 3) / E_{eff} = 0.01147479 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 2.1517E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 1500.00$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 9.3758E+012$$

factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
Ec*Ig = 3.1253E+013

Calculation of Yielding Moment My

Calculation of ρ_y and My according to (7) - (8) in Biskinis and Fardis

My = Min(My_ten, My_com) = 2.1517E+008
 ρ_y ((10a) or (10b)) = 1.1483167E-005
My_ten (8a) = 2.1517E+008
 ρ_{y_ten} (7a) = 72.79826
error of function (7a) = 0.00155288
My_com (8b) = 4.0201E+008
 ρ_{y_com} (7b) = 69.01017
error of function (7b) = -0.00040881
with e_y = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
= 0.3645
with fc = 28.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of ρ_p -

From table 10-9: ρ_p = 0.05987483

with:

- Columns controlled by inadequate development or splicing along the clear height because lb/d < 1

shear control ratio $V_y E / C o l O E$ = 0.51034251

d = 0.00

s = 0.00

t = $2 * A_v / (d c * s) + 4 * t_f / D * (f_{fe} / f_s)$ = 0.00

A_v = 78.53982, is the area of the circular stirrup

dc = D - 2*cover - Hoop Diameter = 340.00

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

NUD = 4770.074

Ag = 125663.706

f'cE = 28.00

fytE = fyIE = 420.00

ρ_l = Area_Tot_Long_Rein/(Ag) = 0.0243

f'cE = 28.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

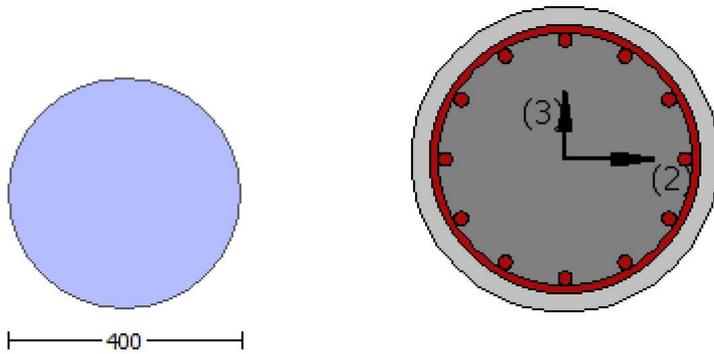
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 28.00$

New material: Steel Strength, $f_s = f_{sm} = 420.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -6.6801918E-012$

Shear Force, $V_a = 5.1847167E-015$

EDGE -B-

Bending Moment, $M_b = -8.9196430E-012$

Shear Force, $V_b = -5.1847167E-015$

BOTH EDGES

Axial Force, $F = -4770.074$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1272.345$

-Compression: $As_c = 1781.283$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1017.876$

-Compression: $As_{c,com} = 1017.876$

-Middle: $As_{mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 270862.328$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 270862.328$

$V_{CoI} = 270862.328$

$k_n = 1.00$

$displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 6.6801918E-012$

$V_u = 5.1847167E-015$

$d = 0.8 \cdot D = 320.00$

$N_u = 4770.074$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 157913.67$

$A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$

$f_y = 400.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 238930.50$

$bw \cdot d = \sqrt{2} \cdot d^2 / 4 = 80424.772$

$displacement_ductility_demand$ is calculated as ϕ / y

- Calculation of ϕ / y for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta = 3.1936934E-021$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.01147479$ ((4.29), Biskinis Phd)

$M_y = 2.1517E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 9.3758E+012$

$factor = 0.30$

$A_g = 125663.706$

$f_c' = 28.00$

$N = 4770.074$

$$E_c \cdot I_g = 3.1253E+013$$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to (7) - (8) in Biskinis and Fardis

$$M_y = \min(M_{y_ten}, M_{y_com}) = 2.1517E+008$$

$$\rho_y \text{ ((10a) or (10b))} = 1.1483167E-005$$

$$M_{y_ten} \text{ (8a)} = 2.1517E+008$$

$$\rho_{y_ten} \text{ (7a)} = 72.79826$$

$$\text{error of function (7a)} = 0.00155288$$

$$M_{y_com} \text{ (8b)} = 4.0201E+008$$

$$\rho_{y_com} \text{ (7b)} = 69.01017$$

$$\text{error of function (7b)} = -0.00040881$$

$$\text{with } e_y = 0.0021$$

$$e_{co} = 0.002$$

$$a_{pl} = 0.35 \text{ ((9a) in Biskinis and Fardis for no FRP Wrap)}$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4770.074$$

$$A_c = 125663.706$$

$$= 0.3645$$

$$\text{with } f_c = 28.00$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

End Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

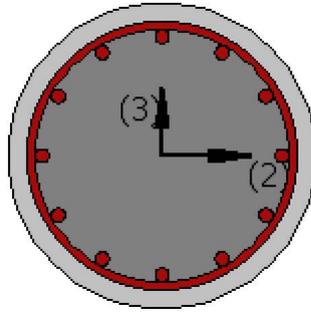
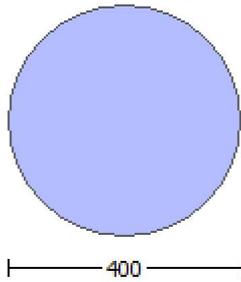
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 24870.062$
 Steel Elasticity, $E_s = 200000.00$

 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 New material: Steel Strength, $f_s = 1.25 * f_{sm} = 525.00$

 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.32561
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou, min} >= 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -3.7372036E-031$
 EDGE -B-
 Shear Force, $V_b = 3.7372036E-031$
 BOTH EDGES
 Axial Force, $F = -4771.233$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{slt} = 0.00$
 -Compression: $A_{slc} = 3053.628$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1017.876$
 -Compression: $A_{sl,com} = 1017.876$
 -Middle: $A_{sl,mid} = 1017.876$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 2.2910E+008$
 $M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 2.2910E+008$
 $M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.2910E+008$

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$
conf. factor $c = 1.32561$
 $f_c = 28.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$
 $l_b/d = 1.00$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00135568$
 $N = 4771.233$
 $A_c = 125663.706$
= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.2910E+008$

= 1.0472
' = 0.92729522
error of function (3.68), Biskinis Phd = 58526.963
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$
conf. factor $c = 1.32561$
 $f_c = 28.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$
 $l_b/d = 1.00$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00135568$
 $N = 4771.233$
 $A_c = 125663.706$
= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.2910E+008$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 525.00$

$$lb/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$Ac = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.3645$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.2910E+008$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 525.00$

$$lb/d = 1.00$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00135568$$

$$N = 4771.233$$

$$Ac = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.3645$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, Vr1 = 299278.805

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCoIO

VCoIO = 299278.805

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

fc' = 28.00, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.0979367E-011

Vu = 3.7372036E-031

d = 0.8*D = 320.00

Nu = 4771.233

Ag = 125663.706

From (11.5.4.8), ACI 318-14: Vs = 165809.354

Av = /2*A_stirrup = 123370.055

fy = 420.00

s = 100.00

Vs is multiplied by Col = 0.00

s/d = 0.3125

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 282706.38

bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCoIO

VCoIO = 299278.805

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

fc' = 28.00, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.0979367E-011

Vu = 3.7372036E-031

d = 0.8*D = 320.00

Nu = 4771.233

Ag = 125663.706

From (11.5.4.8), ACI 318-14: Vs = 165809.354

Av = /2*A_stirrup = 123370.055

fy = 420.00

s = 100.00

Vs is multiplied by Col = 0.00

s/d = 0.3125

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 282706.38

bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rccs

Constant Properties

Knowledge Factor, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
Concrete Elasticity, $E_c = 24870.062$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$

Diameter, $D = 400.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.32561
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -9.8626872E-031$
EDGE -B-
Shear Force, $V_b = 9.8626872E-031$
BOTH EDGES
Axial Force, $F = -4771.233$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1017.876$
-Compression: $A_{sc,com} = 1017.876$
-Middle: $A_{sc,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$
 $M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$
 $M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$$\mu = 2.2910E+008$$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$$\mu = 2.2910E+008$$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ

$$\mu = 2.2910E+008$$

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

lb/d = 1.00
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: fcc = fc* c = 37.11712

conf. factor c = 1.32561

fc = 28.00

From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 525.00

lb/d = 1.00

d1 = 44.00

R = 200.00

v = 0.00135568

N = 4771.233

Ac = 125663.706

= *Min(1,1.25*(lb/d)^ 2/3) = 0.3645

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 299278.805

Calculation of Shear Strength at edge 1, Vr1 = 299278.805

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 299278.805

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

fc' = 28.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 9.9556147E-012

Vu = 9.8626872E-031

d = 0.8*D = 320.00

Nu = 4771.233

Ag = 125663.706

From (11.5.4.8), ACI 318-14: Vs = 165809.354

Av = /2*A_stirup = 123370.055

fy = 420.00

s = 100.00

Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 299278.805
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 299278.805
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*VF'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
fc' = 28.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.9556147E-012
Vu = 9.8626872E-031
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 165809.354
Av = /2*A_stirrup = 123370.055
fy = 420.00
s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/d >= 1)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -8.6921E+006$
Shear Force, $V2 = -2896.171$
Shear Force, $V3 = 5.1847167E-015$
Axial Force, $F = -4770.074$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1272.345$
-Compression: $As_c = 1781.283$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{,ten} = 1017.876$
-Compression: $As_{,com} = 1017.876$
-Middle: $As_{,mid} = 1017.876$
Mean Diameter of Tension Reinforcement, $Db_L = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.08283389$
 $u = \gamma + p = 0.08283389$

- Calculation of γ -

$\gamma = (My * L_s / 3) / E_{eff} = 0.02295907$ ((4.29), Biskinis Phd))
 $My = 2.1517E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3001.241
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 9.3758E+012$
factor = 0.30
 $Ag = 125663.706$
 $fc' = 28.00$
 $N = 4770.074$
 $E_c * I_g = 3.1253E+013$

Calculation of Yielding Moment My

Calculation of γ and My according to (7) - (8) in Biskinis and Fardis

$My = \text{Min}(My_{,ten}, My_{,com}) = 2.1517E+008$
 γ ((10a) or (10b)) = 1.1483167E-005
 $My_{,ten}$ (8a) = 2.1517E+008
 $\gamma_{,ten}$ (7a) = 72.79826
error of function (7a) = 0.00155288
 $My_{,com}$ (8b) = 4.0201E+008
 $\gamma_{,com}$ (7b) = 69.01017
error of function (7b) = -0.00040881
with $e_y = 0.0021$
 $e_{co} = 0.002$
 $apl = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d1 = 44.00$
 $R = 200.00$
 $v = 0.00135568$
 $N = 4770.074$
 $Ac = 125663.706$
= 0.3645
with $fc = 28.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of p -

From table 10-9: $\rho = 0.05987483$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_y E / V_{CoI} E = 0.51034251$

$d = 0.00$

$s = 0.00$

$t = 2 \cdot A_v / (d_c \cdot s) + 4 \cdot t_f / D \cdot (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, is the area of the circular stirrup

$d_c = D - 2 \cdot \text{cover} - \text{Hoop Diameter} = 340.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$NUD = 4770.074$

$Ag = 125663.706$

$f_{cE} = 28.00$

$f_{yE} = f_{yI} = 420.00$

$\rho_l = \text{Area_Tot_Long_Rein} / (Ag) = 0.0243$

$f_{cE} = 28.00$

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

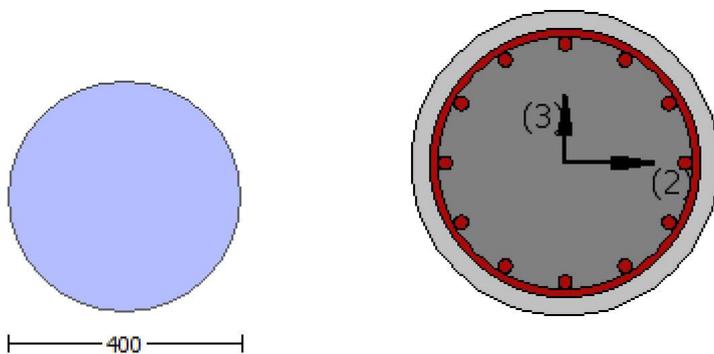
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 28.00$

New material: Steel Strength, $f_s = f_{sm} = 420.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -8.6921E+006$

Shear Force, $V_a = -2896.171$

EDGE -B-

Bending Moment, $M_b = 0.02826837$

Shear Force, $V_b = 2896.171$

BOTH EDGES

Axial Force, $F = -4770.074$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sl,com} = 1017.876$

-Middle: $A_{sl,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 270862.328$

V_n ((10.3), ASCE 41-17) = $k_n l \cdot V_{CoI} = 270862.328$

$V_{CoI} = 270862.328$

$k_n l = 1.00$

$displacement_ductility_demand = 0.06058843$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\gamma = 1$ (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 0.02826837$

$V_u = 2896.171$

$d = 0.8 \cdot D = 320.00$

$N_u = 4770.074$

Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 157913.67
Av = $\sqrt{2} \cdot A_{stirrup} = 123370.055$
fy = 400.00
s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = $\frac{1}{4} \cdot d^2 = 80424.772$

displacement_ductility_demand is calculated as $\frac{1}{y}$

- Calculation of $\frac{1}{y}$ for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 0.00013905
 $y = \frac{M_y \cdot L_s / 3}{E_{eff}} = 0.00229496$ ((4.29), Biskinis Phd)
My = 2.1517E+008
Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 9.3758E+012$
factor = 0.30
Ag = 125663.706
fc' = 28.00
N = 4770.074
 $E_c \cdot I_g = 3.1253E+013$

Calculation of Yielding Moment My

Calculation of $\frac{1}{y}$ and My according to (7) - (8) in Biskinis and Fardis

My = Min(My_ten, My_com) = 2.1517E+008
 y ((10a) or (10b)) = 1.1483167E-005
My_ten (8a) = 2.1517E+008
 $\frac{1}{y}$ (7a) = 72.79826
error of function (7a) = 0.00155288
My_com (8b) = 4.0201E+008
 $\frac{1}{y}$ (7b) = 69.01017
error of function (7b) = -0.00040881
with ey = 0.0021
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
= 0.3645
with fc = 28.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

End Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 14

column C1, Floor 1

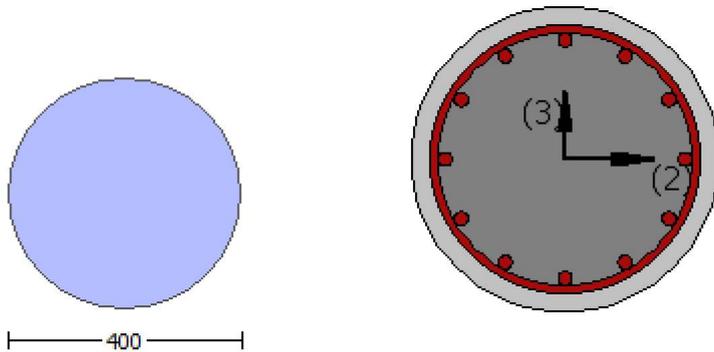
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 525.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.32561

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -3.7372036E-031$

EDGE -B-

Shear Force, $V_b = 3.7372036E-031$

BOTH EDGES

Axial Force, $F = -4771.233$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{sc,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.51034251$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

$\phi = 1.0472$

$\phi' = 0.92729522$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$\phi' \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$Ac = 125663.706$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$Ac = 125663.706$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 2.2910E+008

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

$= * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{\text{Col}}$ ((10.3), ASCE 41-17) = $k_n l * V_{\text{Col}0}$

$V_{\text{Col}0} = 299278.805$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d/s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.0979367E-011$

$\nu_u = 3.7372036E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \sqrt{2} * A_{\text{stirrup}} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $\text{Col} = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w * d = * d * d/4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{\text{Col}}$ ((10.3), ASCE 41-17) = $k_n l * V_{\text{Col}0}$

$V_{\text{Col}0} = 299278.805$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d/s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.0979367E-011$

$\nu_u = 3.7372036E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \sqrt{2} * A_{\text{stirrup}} = 123370.055$

$f_y = 420.00$

s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 282706.38
bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 28.00
New material of Primary Member: Steel Strength, fs = fsm = 420.00
Concrete Elasticity, Ec = 24870.062
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 525.00

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.32561
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/ou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -9.8626872E-031
EDGE -B-
Shear Force, Vb = 9.8626872E-031
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1017.876
-Compression: Asl,com = 1017.876
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.51034251

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 152734.698$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.2910E+008$

$M_{u1+} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.2910E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.2910E+008$

$M_{u2+} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.2910E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u

$M_u = 2.2910E+008$

= 1.0472

' = 0.92729522

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 525.00$

$l_b/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$A_c = 125663.706$

= $\cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 525.00$

$lb/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$Ac = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.2910E+008

$$= 1.0472$$

$$' = 0.92729522$$

error of function (3.68), Biskinis Phd = 58526.963

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 37.11712$

conf. factor $c = 1.32561$

$f_c = 28.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 525.00$

$lb/d = 1.00$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4771.233$

$Ac = 125663.706$

$= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.3645$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 299278.805$

Calculation of Shear Strength at edge 1, $V_{r1} = 299278.805$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 299278.805$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.9556147E-012$

$\nu_u = 9.8626872E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \lambda / 2 * A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w * d = \lambda * d * d / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 299278.805$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 299278.805$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$ (normal-weight concrete)

$f_c' = 28.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.9556147E-012$

$\nu_u = 9.8626872E-031$

$d = 0.8 * D = 320.00$

$N_u = 4771.233$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 165809.354$

$A_v = \lambda / 2 * A_{stirrup} = 123370.055$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 282706.38$

$b_w * d = \lambda * d * d / 4 = 80424.772$

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\phi = 1.00$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 28.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 420.00$
 Concrete Elasticity, $E_c = 24870.062$
 Steel Elasticity, $E_s = 200000.00$
 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -8.9196430E-012$
 Shear Force, $V_2 = 2896.171$
 Shear Force, $V_3 = -5.1847167E-015$
 Axial Force, $F = -4770.074$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 3053.628$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1017.876$
 -Compression: $A_{st,com} = 1017.876$
 -Middle: $A_{st,mid} = 1017.876$
 Mean Diameter of Tension Reinforcement, $D_bL = 18.00$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.07134961$
 $u = y + p = 0.07134961$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01147479$ ((4.29), Biskinis Phd))
 $M_y = 2.1517E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 9.3758E+012$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 28.00$
 $N = 4770.074$
 $E_c * I_g = 3.1253E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to (7) - (8) in Biskinis and Fardis

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.1517E+008$
 y ((10a) or (10b)) = $1.1483167E-005$
 M_{y_ten} (8a) = $2.1517E+008$
 $_{ten}$ (7a) = 72.79826
 error of function (7a) = 0.00155288
 M_{y_com} (8b) = $4.0201E+008$
 $_{com}$ (7b) = 69.01017

error of function (7b) = -0.00040881

with $\epsilon_y = 0.0021$

$\epsilon_{co} = 0.002$

$\alpha_{pl} = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)

$d_1 = 44.00$

$R = 200.00$

$v = 0.00135568$

$N = 4770.074$

$A_c = 125663.706$

$= 0.3645$

with $f_c = 28.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of ρ -

From table 10-9: $\rho = 0.05987483$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/d < 1$

shear control ratio $V_y E / C_o I_o E = 0.51034251$

$d = 0.00$

$s = 0.00$

$t = 2 \cdot A_v / (d_c \cdot s) + 4 \cdot t_f / D \cdot (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, is the area of the circular stirrup

$d_c = D - 2 \cdot \text{cover} - \text{Hoop Diameter} = 340.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$N_{UD} = 4770.074$

$A_g = 125663.706$

$f_{cE} = 28.00$

$f_{yE} = f_{yIE} = 420.00$

$\rho_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0243$

$f_{cE} = 28.00$

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

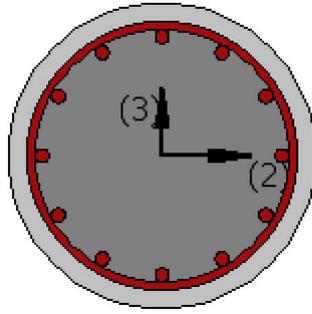
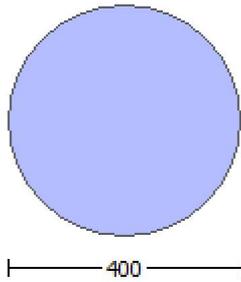
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 24870.062$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 28.00$

New material: Steel Strength, $f_s = f_{sm} = 420.00$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -6.6801918E-012$

Shear Force, $V_a = 5.1847167E-015$

EDGE -B-

Bending Moment, $M_b = -8.9196430E-012$

Shear Force, $V_b = -5.1847167E-015$

BOTH EDGES

Axial Force, $F = -4770.074$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3053.628$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1017.876$

-Compression: $A_{st,com} = 1017.876$

-Middle: $A_{st,mid} = 1017.876$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.00$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 270862.328$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 270862.328$
 $V_{CoI} = 270862.328$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 8.9196430E-012$
 $V_u = 5.1847167E-015$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4770.074$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 157913.67$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $CoI = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 238930.50$
 $b_w \cdot d = \sqrt{4} \cdot d = 80424.772$

 $displacement_ductility_demand$ is calculated as δ / y

- Calculation of δ / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 2.5100185E-022$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.01147479$ ((4.29), Biskinis Phd))
 $M_y = 2.1517E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 9.3758E+012$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 28.00$
 $N = 4770.074$
 $E_c \cdot I_g = 3.1253E+013$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to (7) - (8) in Biskinis and Fardis

 $M_y = \min(M_{y_ten}, M_{y_com}) = 2.1517E+008$
 y ((10a) or (10b)) = 1.1483167E-005
 M_{y_ten} (8a) = 2.1517E+008
 δ_{ten} (7a) = 72.79826
error of function (7a) = 0.00155288
 M_{y_com} (8b) = 4.0201E+008
 δ_{com} (7b) = 69.01017
error of function (7b) = -0.00040881
with $e_y = 0.0021$
 $e_{co} = 0.002$
 $apl = 0.35$ ((9a) in Biskinis and Fardis for no FRP Wrap)
 $d1 = 44.00$

R = 200.00
v = 0.00135568
N = 4770.074
Ac = 125663.706
= 0.3645

with $f_c = 28.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

End Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 3

Integration Section: (b)