

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

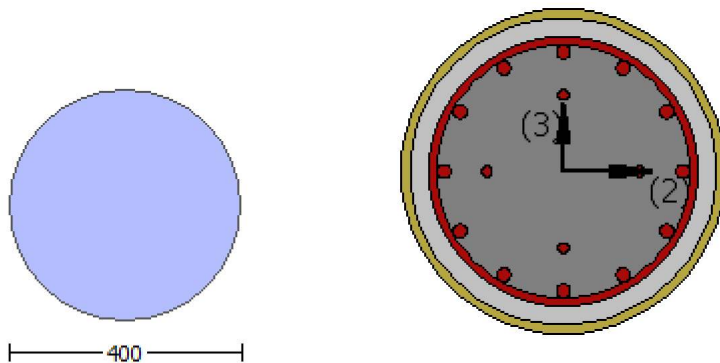
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

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Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $NoDir = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3625E+007$

Shear Force, $V_a = -4539.895$

EDGE -B-

Bending Moment, $M_b = 0.03889518$

Shear Force, $V_b = 4539.895$

BOTH EDGES

Axial Force, $F = -4819.292$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1426.283$

-Compression: $As_c = 2243.097$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 1223.127$

-Compression: $As_{l,com} = 1223.127$

-Middle: $As_{l,mid} = 1223.127$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.20$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 330221.669$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 330221.669$

$V_{CoI} = 330221.669$

$k_n = 1.00$

displacement_ductility_demand = 0.01800015

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

= 1 (normal-weight concrete)

$f'_c = 25.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 1.3625E+007$

$V_u = 4539.895$

$d = 0.8 \cdot D = 320.00$

$Nu = 4819.292$
 $Ag = 125663.706$
 From (11.5.4.8), ACI 318-14: $Vs = 197392.088$
 $Av = \frac{1}{2} * A_{stirrup} = 123370.055$
 $fy = 500.00$
 $s = 100.00$
 Vs is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 Vf ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $Vf(\theta)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $Vf = \text{Min}(|Vf(45, \theta)|, |Vf(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 259.312
 $Ef = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
 with $fu = 0.01$
 From (11-11), ACI 440: $Vs + Vf \leq 267132.42$
 $bw * d = \frac{1}{4} * d * d = 80424.772$

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 $\theta = 0.00036405$
 $y = (My * Ls / 3) / Eleff = 0.02022461$ ((4.29), Biskinis Phd))
 $My = 2.0578E+008$
 $Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 3001.156
 From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 1.0179E+013$
 $factor = 0.30$
 $Ag = 125663.706$
 $fc' = 33.00$
 $N = 4819.292$
 $Ec * Ig = 3.3929E+013$

Calculation of Yielding Moment My

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

$My = \text{Min}(My_{ten}, My_{com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 My_{ten} (8c) = 2.0578E+008
 δ_{ten} (7c) = 69.48506
 error of function (7c) = 0.00456662
 My_{com} (8d) = 5.0781E+008
 δ_{com} (7d) = 68.37715
 error of function (7d) = -0.00101203
 with ((10.1), ASCE 41-17) $ey = \text{Min}(ey, 1.25 * ey * (lb/l_d)^{2/3}) = 0.0027778$
 $eco = 0.002$
 $apl = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d1 = 44.00$
 $R = 200.00$
 $v = 0.00103288$
 $N = 4819.292$
 $Ac = 125663.706$
 ((10.1), ASCE 41-17) $\delta = \text{Min}(\delta, 1.25 * \delta * (lb/l_d)^{2/3}) = 0.4369098$

with f_c^* ((12.3), ACI 440) = 37.12975
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 e_{fe} ((12.5) and (12.7)) = 0.004
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

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

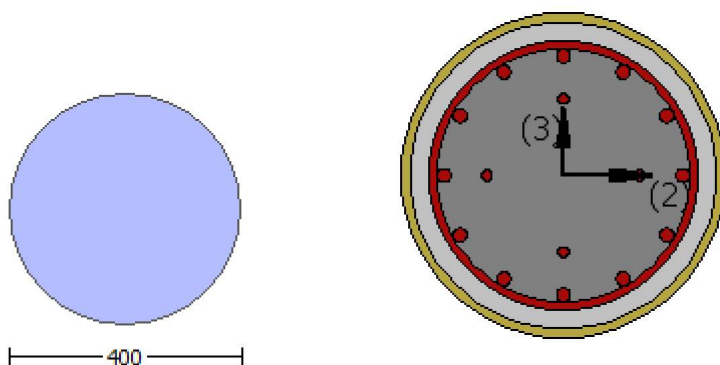
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\phi = 1.00$

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

Consequently:

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 8.8188366E-032$

EDGE -B-

Shear Force, $V_b = -8.8188366E-032$

BOTH EDGES

Axial Force, $F = -4821.109$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3669.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1223.127$

-Compression: $As_{l,com} = 1223.127$

-Middle: $As_{l,mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$

with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.1596E+008$

$\mu_{u1+} = 2.1596E+008$, 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

$\mu_{u1-} = 2.1596E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.1596E+008$

$\mu_{u2+} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

$\phi = 0.9424778$
 $\phi' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TDY: $f_{cc} = f_c' \cdot c = 51.61391$
 conf. factor $c = 1.56406$
 $f_c = 33.00$
 From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $\phi \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_2 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$\phi = 0.9424778$
 $\phi' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TDY: $f_{cc} = f_c' \cdot c = 51.61391$
 conf. factor $c = 1.56406$
 $f_c = 33.00$
 From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $\phi \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

$V_{r1} = V_{co1}$ ((10.3), ASCE 41-17) = $k_n \cdot V_{co1}$

$V_{co1} = 451737.695$

$k_n = 1$ (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).

$\phi = 1$ (normal-weight concrete)
 $f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa ((22.5.3.1, ACI 318-14)
 $M/d = 2.00$
 $\mu = 1.1386922E-011$
 $V_u = 8.8188366E-032$

$d = 0.8 \cdot D = 320.00$
 $Nu = 4821.109$
 $Ag = 125663.706$
 From (11.5.4.8), ACI 318-14: $Vs = 219326.297$
 $Av = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $fy = 555.56$
 $s = 100.00$
 Vs is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 Vf ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $Vf(\theta)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = b_1 + 90^\circ = 90.00$
 $Vf = \text{Min}(|Vf(45, \theta_1)|, |Vf(-45, a_1)|)$, with:
 total thickness per orientation, $tf_1 = NL \cdot t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 259.312
 $Ef = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
 with $fu = 0.01$
 From (11-11), ACI 440: $Vs + Vf \leq 306911.784$
 $bw \cdot d = \frac{1}{4} \cdot d^2 = 80424.772$

Calculation of Shear Strength at edge 2, $Vr2 = 451737.695$
 $Vr2 = VCol$ ((10.3), ASCE 41-17) = $knl \cdot VColO$
 $VColO = 451737.695$
 $knl = 1$ (zero step-static loading)

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

$\beta = 1$ (normal-weight concrete)
 $fc' = 33.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 1.1386922E-011$
 $Vu = 8.8188366E-032$
 $d = 0.8 \cdot D = 320.00$
 $Nu = 4821.109$
 $Ag = 125663.706$
 From (11.5.4.8), ACI 318-14: $Vs = 219326.297$
 $Av = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $fy = 555.56$
 $s = 100.00$
 Vs is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 Vf ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $Vf(\theta)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = b_1 + 90^\circ = 90.00$
 $Vf = \text{Min}(|Vf(45, \theta_1)|, |Vf(-45, a_1)|)$, with:
 total thickness per orientation, $tf_1 = NL \cdot t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 259.312
 $Ef = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
 with $fu = 0.01$
 From (11-11), ACI 440: $Vs + Vf \leq 306911.784$
 $bw \cdot d = \frac{1}{4} \cdot d^2 = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{dir} = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -5.3998017E-048$

EDGE -B-

Shear Force, $V_b = 5.3998017E-048$

BOTH EDGES

Axial Force, $F = -4821.109$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 3669.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1223.127$

-Compression: $A_{sl,com} = 1223.127$

-Middle: $A_{sl,mid} = 1223.127$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.31871182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.1596E+008$

$M_{u1+} = 2.1596E+008$, 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

$M_{u1-} = 2.1596E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.1596E+008$

$M_{u2+} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.1596E+008$

$\phi = 0.9424778$

$\phi' = 0.8362801$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TB DY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

$= \phi' \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.1596E+008$

$\phi = 0.9424778$

$\phi' = 0.8362801$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TB DY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$$A_c = 125663.706$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596 \times 10^8$

$$= 0.9424778$$

$$\lambda = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596 \times 10^8$

$$= 0.9424778$$

$$\lambda = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

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

$V_{Col0} = 451737.695$

$k_{nl} = 1$ (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)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$\nu_u = 5.3998017E-048$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 194961.134$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation θ_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L * t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$

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

$V_{Col0} = 451737.695$

$k_{nl} = 1$ (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)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$\nu_u = 5.3998017E-048$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

$V_f((11-3)-(11.4), \text{ACI } 440) = 194961.134$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(,)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $= 45^\circ$ and $= -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = NL * t / \text{NoDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

$f_{fe}((11-5), \text{ACI } 440) = 259.312$

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

$b_w * d = \frac{V_s * d}{4} = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $e_{fu} = 0.01$

Number of directions, $\text{NoDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 9.0989575E-010$

Shear Force, $V_2 = -4539.895$

Shear Force, $V_3 = -3.1724095E-013$

Axial Force, $F = -4819.292$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1426.283$
 -Compression: $As_c = 2243.097$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{ten} = 1223.127$
 -Compression: $As_{com} = 1223.127$
 -Middle: $As_{mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $Db_L = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.01010841$
 $u = y + p = 0.01010841$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.01010841$ ((4.29), Biskinis Phd))
 $My = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.0179E+013$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.292$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment My

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

$My = \min(My_{ten}, My_{com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 $My_{ten} (8c) = 2.0578E+008$
 $_{ten} (7c) = 69.48506$
 error of function (7c) = 0.00456662
 $My_{com} (8d) = 5.0781E+008$
 $_{com} (7d) = 68.37715$
 error of function (7d) = -0.00101203
 with ((10.1), ASCE 41-17) $ey = \min(ey, 1.25 * ey * (I_b / I_d)^{2/3}) = 0.0027778$
 $eco = 0.002$
 $apl = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d1 = 44.00$
 $R = 200.00$
 $v = 0.00103288$
 $N = 4819.292$
 $A_c = 125663.706$
 ((10.1), ASCE 41-17) $= \min(, 1.25 * (I_b / I_d)^{2/3}) = 0.4369098$
 with $f_c' ((12.3), ACI 440) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
 Effective FRP thickness, $t_f = NL * t * \cos(b1) = 1.016$
 $efe ((12.5) \text{ and } (12.7)) = 0.004$
 $fu = 0.01$
 $E_f = 64828.00$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- Calculation of p -

From table 10-9: $p = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_y E / V_{col} E = 0.31871182$

$d = 0.00$

$s = 0.00$

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

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

$d_c = D - 2 \cdot \text{cover}$ - 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.

$NUD = 4819.292$

$Ag = 125663.706$

$f_{cE} = 33.00$

$f_{yE} = f_{yL} = 555.56$

$p_l = \text{Area_Tot_Long_Rein} / (Ag) = 0.0292$

$f_{cE} = 33.00$

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

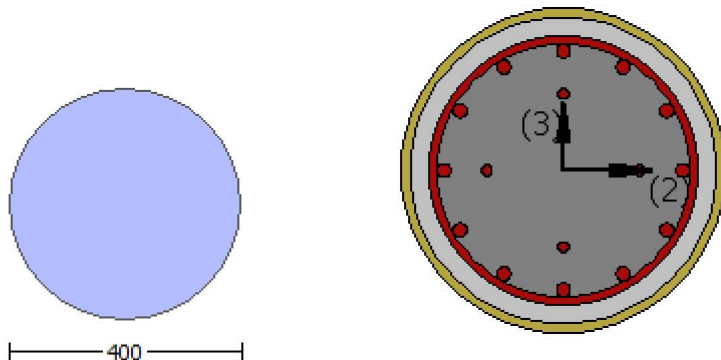
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
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, $f_c = f_{cm} = 33.00$
New material: Steel Strength, $f_s = f_{sm} = 555.56$

Diameter, $D = 400.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $e_{fu} = 0.01$
Number of directions, $N_{oDir} = 1$
Fiber orientations, $b_i: 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = 9.0989575E-010$
Shear Force, $V_a = -3.1724095E-013$
EDGE -B-
Bending Moment, $M_b = 4.2202164E-011$
Shear Force, $V_b = 3.1724095E-013$
BOTH EDGES
Axial Force, $F = -4819.292$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1426.283$
-Compression: $As_c = 2243.097$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1223.127$
-Compression: $As_{l,com} = 1223.127$
-Middle: $As_{l,mid} = 1223.127$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.20$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 393310.919$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 393310.919$

V_{Col} = 393310.919
k_{nl} = 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).

= 1 (normal-weight concrete)
f_c' = 25.00, but f_c'^{0.5} ≤ 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
μ_u = 9.0989575E-010
ν_u = 3.1724095E-013
d = 0.8*D = 320.00
N_u = 4819.292
A_g = 125663.706
From (11.5.4.8), ACI 318-14: V_s = 197392.088
A_v = /2*A_{stirrup} = 123370.055
f_y = 500.00
s = 100.00
V_s is multiplied by Col = 0.00
s/d = 0.3125
V_f ((11-3)-(11.4), ACI 440) = 194961.134
f = 0.95, for fully-wrapped sections
w_f/s_f = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot + cota)sinα which is more a generalised expression,
where α is the angle of the crack direction (see KANEPE).
This later relation, considered as a function V_f(α), is implemented for every different fiber orientation α_i,
as well as for 2 crack directions, α = 45° and α = -45° to take into consideration the cyclic seismic loading.
orientation 1: α = α₁ + 90° = 90.00
V_f = Min(|V_f(45, α₁)|, |V_f(-45, α₁)|), with:
total thickness per orientation, t_{f1} = N_L*t/NoDir = 1.016
d_{f1} = d (figure 11.2, ACI 440) = 370.00
f_{fe} ((11-5), ACI 440) = 259.312
E_f = 64828.00
f_ε = 0.004, from (11.6a), ACI 440
with f_u = 0.01
From (11-11), ACI 440: V_s + V_f ≤ 267132.42
b_w*d = *d*d/4 = 80424.772

displacement_ductility_demand is calculated as δ / γ

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

From analysis, chord rotation = 2.6026501E-020
γ = (M_y*L_s/3)/E_{leff} = 0.01010841 ((4.29), Biskinis Phd))
M_y = 2.0578E+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_{leff} = factor*E_c*I_g = 1.0179E+013
factor = 0.30
A_g = 125663.706
f_c' = 33.00
N = 4819.292
E_c*I_g = 3.3929E+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}) = 2.0578E+008
δ_y = 9.1038064E-006
M_{y_ten} (8c) = 2.0578E+008
δ_{y_ten} (7c) = 69.48506

error of function (7c) = 0.00456662
 My_com (8d) = 5.0781E+008
 _com (7d) = 68.37715
 error of function (7d) = -0.00101203
 with ((10.1), ASCE 41-17) ey = Min(ey, $1.25 \cdot e_y \cdot (l_b/l_d)^{2/3}$) = 0.0027778
 eco = 0.002
 apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
 d1 = 44.00
 R = 200.00
 v = 0.00103288
 N = 4819.292
 Ac = 125663.706
 ((10.1), ASCE 41-17) = Min(, $1.25 \cdot \cdot (l_b/l_d)^{2/3}$) = 0.4369098
 with fc* ((12.3), ACI 440) = 37.12975
 fc = 33.00
 fl = 1.3173
 k = 1
 Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
 efe ((12.5) and (12.7)) = 0.004
 fu = 0.01
 Ef = 64828.00

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

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

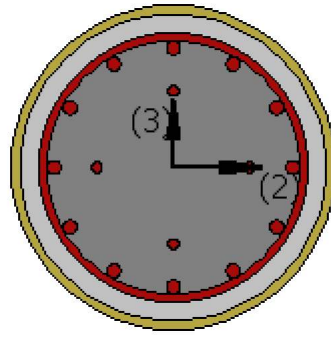
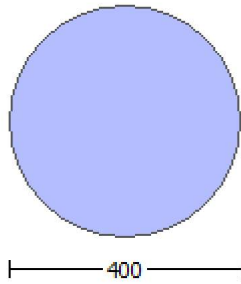
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 8.8188366E-032$

EDGE -B-

Shear Force, $V_b = -8.8188366E-032$

BOTH EDGES

Axial Force, $F = -4821.109$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $Aslt = 0.00$
 -Compression: $Aslc = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl,ten = 1223.127$
 -Compression: $Asl,com = 1223.127$
 -Middle: $Asl,mid = 1223.127$

Calculation of Shear Capacity ratio , $Ve/Vr = 0.31871182$
 Member Controlled by Flexure ($Ve/Vr < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $Ve = (Mpr1 + Mpr2)/ln = 143974.143$
 with

$Mpr1 = \text{Max}(Mu1+ , Mu1-) = 2.1596E+008$
 $Mu1+ = 2.1596E+008$, 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
 $Mu1- = 2.1596E+008$, 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
 $Mpr2 = \text{Max}(Mu2+ , Mu2-) = 2.1596E+008$
 $Mu2+ = 2.1596E+008$, 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
 $Mu2- = 2.1596E+008$, 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 $Mu1+$

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
 $Mu = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TBDY: $fcc = fc \cdot c = 51.61391$
 conf. factor $c = 1.56406$
 $fc = 33.00$
 From 10.3.5, ASCE41-17, Final value of $f_y: f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 389.0139$
 $lb/d = 0.30$
 $d1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $Ac = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 0.30415227$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of $Mu1-$

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
 $Mu = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TBDY: $fcc = fc \cdot c = 51.61391$
 conf. factor $c = 1.56406$

$f_c = 33.00$
 From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $Ac = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
 conf. factor $c = 1.56406$
 $f_c = 33.00$
 From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $Ac = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
 conf. factor $c = 1.56406$
 $f_c = 33.00$
 From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $Ac = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

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

$V_{\text{ColO}} = 451737.695$

$k_n l = 1$ (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)

$f'_c = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.1386922\text{E-}011$

$\nu_u = 8.8188366\text{E-}032$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 194961.134$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

$b_w \cdot d = \sqrt{2} \cdot d^2 / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$

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

$V_{\text{ColO}} = 451737.695$

$k_n l = 1$ (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)

$f'_c = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 1.1386922\text{E-}011$

$\nu_u = 8.8188366\text{E-}032$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \frac{1}{2} A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe} ((11-5), \text{ACI } 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w * d = \frac{1}{4} * d * d = 80424.772$

 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_s = 1.25 * f_{sm} = 694.45$
 #####
 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.56406
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou, \min} = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$
Number of directions, $NoDir = 1$
Fiber orientations, $bi = 0.00^\circ$
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -5.3998017E-048$
EDGE -B-
Shear Force, $V_b = 5.3998017E-048$
BOTH EDGES
Axial Force, $F = -4821.109$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3669.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{ten} = 1223.127$
-Compression: $As_{com} = 1223.127$
-Middle: $As_{mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.1596E+008$
 $\mu_{u1+} = 2.1596E+008$, 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
 $\mu_{u1-} = 2.1596E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.1596E+008$
 $\mu_{u2+} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \min(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

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

$V_{ColO} = 451737.695$

$k_{nl} = 1$ (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)
 $f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 4.3208129E-012$
 $V_u = 5.3998017E-048$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w \cdot d = \cdot d \cdot d/4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$

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

$V_{Col0} = 451737.695$

$k_{nl} = 1$ (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).

$= 1$ (normal-weight concrete)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$\nu_u = 5.3998017E-048$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 194961.134$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,

where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L * t / N_{oDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$

$E_f = 64828.00$

$f_{fe} = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

$b_w * d = \frac{1}{4} * d * d = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i = 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = -1.3625E+007$
 Shear Force, $V_2 = -4539.895$
 Shear Force, $V_3 = -3.1724095E-013$
 Axial Force, $F = -4819.292$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 1426.283$
 -Compression: $A_{sc} = 2243.097$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1223.127$
 -Compression: $A_{st,com} = 1223.127$
 -Middle: $A_{st,mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $D_{bL} = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_{u,R} = 1.0^*$ $\phi_u = 0.02022461$
 $\phi_u = \phi_y + \phi_p = 0.02022461$

- Calculation of ϕ_y -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.02022461$ ((4.29), Biskinis Phd))
 $M_y = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3001.156
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.0179E+013$
 factor = 0.30
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.292$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $\phi_y = 9.1038064E-006$
 $M_{y_ten} (8c) = 2.0578E+008$
 $\phi_{y_ten} (7c) = 69.48506$
 error of function (7c) = 0.00456662
 $M_{y_com} (8d) = 5.0781E+008$
 $\phi_{y_com} (7d) = 68.37715$
 error of function (7d) = -0.00101203

with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103288$
 $N = 4819.292$
 $A_c = 125663.706$
 ((10.1), ASCE 41-17) $= \text{Min}(, 1.25 * (l_b / l_d)^{2/3}) = 0.4369098$
 with $f_c^* ((12.3), \text{ACI 440}) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
 Effective FRP thickness, $t_f = N L * t * \text{Cos}(\theta_1) = 1.016$
 $e_{fe} ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$

 Calculation of ratio l_b / l_d

 Inadequate Lap Length with $l_b / l_d = 0.30$

 - Calculation of p -

 From table 10-9: $p = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b / l_d \geq 1$

shear control ratio $V_y E / V_{colOE} = 0.31871182$

$d = 0.00$

$s = 0.00$

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

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

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

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.

$N_{UD} = 4819.292$

$A_g = 125663.706$

$f_{cE} = 33.00$

$f_{ytE} = f_{yIE} = 555.56$

$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0292$

$f_{cE} = 33.00$

 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

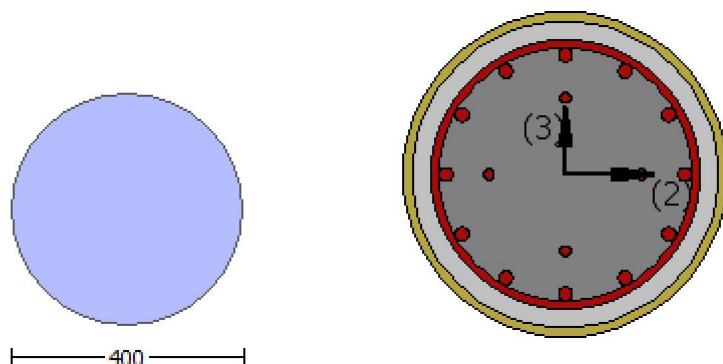
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $efu = 0.01$

Number of directions, $NoDir = 1$

Fiber orientations, θ_i : 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, M_a = -1.3625E+007
Shear Force, V_a = -4539.895
EDGE -B-
Bending Moment, M_b = 0.03889518
Shear Force, V_b = 4539.895
BOTH EDGES
Axial Force, F = -4819.292
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: A_{st} = 0.00
-Compression: A_{sc} = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten}$ = 1223.127
-Compression: $A_{sc,com}$ = 1223.127
-Middle: $A_{sc,mid}$ = 1223.127
Mean Diameter of Tension Reinforcement, $D_{bL,ten}$ = 17.20

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 393310.919$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col0} = 393310.919$
 $V_{Col} = 393310.919$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.09930763$

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)
 $f'_c = 25.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.03889518$
 $V_u = 4539.895$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4819.292$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_s is multiplied by $\phi_{Col} = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
total thickness per orientation, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 267132.42$
 $b_w \cdot d = \phi \cdot d \cdot d / 4 = 80424.772$

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 $\theta = 0.00020077$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00202168$ ((4.29), Biskinis Phd))
 $M_y = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.0179E+013$
factor = 0.30
Ag = 125663.706
fc' = 33.00
N = 4819.292
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 $M_{y_ten} (8c) = 2.0578E+008$
 $\phi_{ten} (7c) = 69.48506$
error of function (7c) = 0.00456662
 $M_{y_com} (8d) = 5.0781E+008$
 $\phi_{com} (7d) = 68.37715$
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00103288
N = 4819.292
Ac = 125663.706
((10.1), ASCE 41-17) $\phi = \min(\phi, 1.25 * \phi * (I_b / I_d)^{2/3}) = 0.4369098$
with fc' ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
k = 1
Effective FRP thickness, $t_f = N L * t * \cos(b1) = 1.016$
efe ((12.5) and (12.7)) = 0.004
fu = 0.01
Ef = 64828.00

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

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

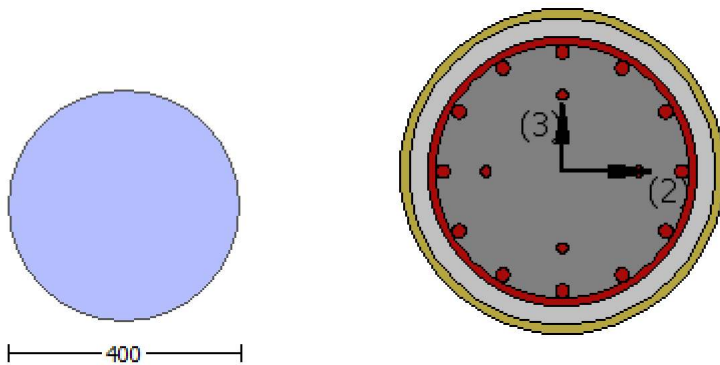
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $e_{fu} = 0.01$
Number of directions, $NoDir = 1$
Fiber orientations, $bi = 0.00^\circ$
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 8.8188366E-032$
EDGE -B-
Shear Force, $V_b = -8.8188366E-032$
BOTH EDGES
Axial Force, $F = -4821.109$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3669.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1223.127$
-Compression: $As_{l,com} = 1223.127$
-Middle: $As_{l,mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.1596E+008$
 $\mu_{u1+} = 2.1596E+008$, 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
 $\mu_{u1-} = 2.1596E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.1596E+008$
 $\mu_{u2+} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$

$\phi = 0.9424778$
 $\phi' = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y * \min(1, 1.25 * (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $\phi' * \min(1, 1.25 * (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.1596E+008$

$\phi = 0.9424778$
 $\lambda = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c \cdot \lambda = 51.61391$
conf. factor $\lambda = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $\phi \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

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

$V_{ColO} = 451737.695$

$k_{nl} = 1$ (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).

$\phi = 1$ (normal-weight concrete)
 $f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 1.1386922E-011$
 $V_u = 8.8188366E-032$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \phi / 2 \cdot A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\phi_{Col} = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w d = \frac{A_s f_y}{4} = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n V_{Col0}$
 $V_{Col0} = 451737.695$
 $k_n = 1$ (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).

$k_n = 1$ (normal-weight concrete)
 $f'_c = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa ((22.5.3.1), ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.1386922E-011$
 $\nu_u = 8.8188366E-032$
 $d = 0.8D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From ((11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \frac{1}{2} A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$

V_s is multiplied by $\phi_{col} = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 194961.134

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In ((11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation θ_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L t / N_{oDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$, from ((11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

$b_w d = \frac{A_s f_y}{4} = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -5.3998017E-048$

EDGE -B-

Shear Force, $V_b = 5.3998017E-048$

BOTH EDGES

Axial Force, $F = -4821.109$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{slt} = 0.00$

-Compression: $A_{slc} = 3669.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1223.127$

-Compression: $A_{sl,com} = 1223.127$

-Middle: $A_{sl,mid} = 1223.127$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.31871182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$

with

$M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 2.1596E+008$

$\mu_{u1+} = 2.1596E+008$, 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

$\mu_{u1-} = 2.1596E+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 2.1596E+008$

$\mu_{u2+} = 2.1596E+008$, 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

$\mu_{u2-} = 2.1596E+008$, 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 μ_{u1+}

38

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_2 -

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

$$\mu = 2.1596 \times 10^8$$

$$= 0.9424778$$

$$\mu' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

$$\text{conf. factor } c = 1.56406$$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

$$V_{r1} = V_{co1} \text{ ((10.3), ASCE 41-17)} = k_n l \cdot V_{co10}$$

$$V_{co10} = 451737.695$$

$$k_n l = 1 \text{ (zero step-static loading)}$$

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).

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

$$f_c' = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$\mu = 4.3208129 \times 10^{-12}$$

$$V_u = 5.3998017 \times 10^{-48}$$

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

$$N_u = 4821.109$$

$$A_g = 125663.706$$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$$f_y = 555.56$$

$s = 100.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), ACI 440) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
where a is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(,)$, is implemented for every different fiber orientation a_i ,
as well as for 2 crack directions, $= 45^\circ$ and $= -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $tf_1 = NL \cdot t / NoDir = 1.016$
 $df_v = d$ (figure 11.2, ACI 440) = 370.00
 $ffe ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
with $fu = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $bw \cdot d = \cdot d \cdot d / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{ColO}$
 $V_{ColO} = 451737.695$
 $knl = 1$ (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)
 $fc' = 33.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 4.3208129E-012$
 $\mu_v = 5.3998017E-048$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \cdot / 2 \cdot A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), ACI 440) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
where a is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(,)$, is implemented for every different fiber orientation a_i ,
as well as for 2 crack directions, $= 45^\circ$ and $= -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $tf_1 = NL \cdot t / NoDir = 1.016$
 $df_v = d$ (figure 11.2, ACI 440) = 370.00
 $ffe ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
with $fu = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $bw \cdot d = \cdot d \cdot d / 4 = 80424.772$

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: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 4.2202164E-011$

Shear Force, $V_2 = 4539.895$

Shear Force, $V_3 = 3.1724095E-013$

Axial Force, $F = -4819.292$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 3669.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1223.127$

-Compression: $A_{sl,com} = 1223.127$

-Middle: $A_{sl,mid} = 1223.127$

Mean Diameter of Tension Reinforcement, $D_{bL} = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\phi_{u,R} = 1.0^*$ $\phi_u = 0.01010841$

$\phi_u = \phi_y + \phi_p = 0.01010841$

- Calculation of ϕ_y -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.01010841$ ((4.29), Biskinis Phd))

$M_y = 2.0578E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.0179E+013$

factor = 0.30
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.292$
 $E_c I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $\gamma = 9.1038064E-006$
 $M_{y_ten} (8c) = 2.0578E+008$
 $\gamma_{ten} (7c) = 69.48506$
error of function (7c) = 0.00456662
 $M_{y_com} (8d) = 5.0781E+008$
 $\gamma_{com} (7d) = 68.37715$
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) $\gamma_y = \min(\gamma_y, 1.25 \cdot \gamma_y \cdot (I_b/I_d)^{2/3}) = 0.0027778$
 $\epsilon_{co} = 0.002$
 $\alpha_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103288$
 $N = 4819.292$
 $A_c = 125663.706$
((10.1), ASCE 41-17) $\gamma = \min(\gamma, 1.25 \cdot \gamma \cdot (I_b/I_d)^{2/3}) = 0.4369098$
with $f_c' ((12.3), ACI 440) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = N L \cdot t \cdot \cos(b_1) = 1.016$
 $\epsilon_{fe} ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

- Calculation of p -

From table 10-9: $p = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$

shear control ratio $V_y E / V_{CoI} E = 0.31871182$

$d = 0.00$

$s = 0.00$

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

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

$d_c = D - 2 \cdot \text{cover}$ - 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.

$N_{UD} = 4819.292$

$A_g = 125663.706$

$f_{cE} = 33.00$

$f_{ytE} = f_{ylE} = 555.56$

$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0292$

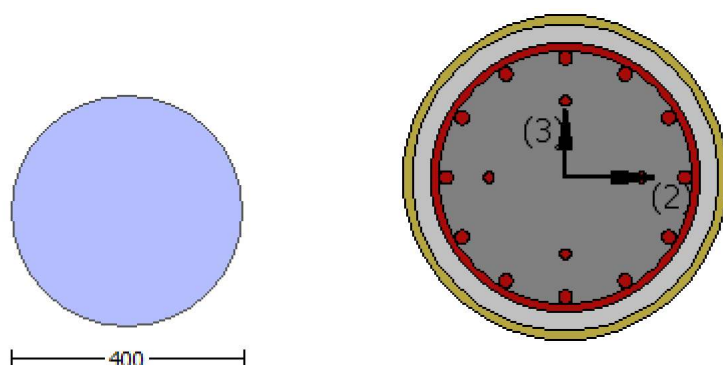
$f_{cE} = 33.00$

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: Operational Level (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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 Number of directions, $NoDir = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $NL = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = 9.0989575E-010$
 Shear Force, $V_a = -3.1724095E-013$
 EDGE -B-
 Bending Moment, $M_b = 4.2202164E-011$
 Shear Force, $V_b = 3.1724095E-013$
 BOTH EDGES
 Axial Force, $F = -4819.292$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1223.127$
 -Compression: $A_{st,com} = 1223.127$
 -Middle: $A_{st,mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.20$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 393310.919$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 393310.919$
 $V_{CoI} = 393310.919$
 $k_n = 1.00$
 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)
 $f'_c = 25.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 4.2202164E-011$
 $V_u = 3.1724095E-013$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4819.292$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = /2 \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_s is multiplied by $CoI = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections

$wf/sf = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $Vf(\theta, a)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = b1 + 90^\circ = 90.00$

$Vf = \text{Min}(|Vf(45, \theta)|, |Vf(-45, a1)|)$, with:

total thickness per orientation, $tf1 = NL \cdot t / \text{NoDir} = 1.016$

$dfv = d$ (figure 11.2, ACI 440) = 370.00

ffe ((11-5), ACI 440) = 259.312

$Ef = 64828.00$

$fe = 0.004$, from (11.6a), ACI 440

with $fu = 0.01$

From (11-11), ACI 440: $Vs + Vf \leq 267132.42$

$bw \cdot d = \frac{V}{\phi \cdot f_v} = 80424.772$

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 $\theta = 1.1801063E-020$

$y = (My \cdot Ls / 3) / Eleff = 0.01010841$ ((4.29), Biskinis Phd))

$My = 2.0578E+008$

$Ls = M/V$ (with $Ls > 0.1 \cdot L$ and $Ls < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $Eleff = \text{factor} \cdot Ec \cdot Ig = 1.0179E+013$

factor = 0.30

$Ag = 125663.706$

$fc' = 33.00$

$N = 4819.292$

$Ec \cdot Ig = 3.3929E+013$

Calculation of Yielding Moment My

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

$My = \text{Min}(My_{ten}, My_{com}) = 2.0578E+008$

$y = 9.1038064E-006$

My_{ten} (8c) = 2.0578E+008

$_{ten}$ (7c) = 69.48506

error of function (7c) = 0.00456662

My_{com} (8d) = 5.0781E+008

$_{com}$ (7d) = 68.37715

error of function (7d) = -0.00101203

with ((10.1), ASCE 41-17) $ey = \text{Min}(ey, 1.25 \cdot ey \cdot (lb/ld)^{2/3}) = 0.0027778$

$eco = 0.002$

$apl = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)

$d1 = 44.00$

$R = 200.00$

$v = 0.00103288$

$N = 4819.292$

$Ac = 125663.706$

((10.1), ASCE 41-17) $= \text{Min}(\frac{V}{\phi \cdot f_v}, 1.25 \cdot \frac{V}{\phi \cdot f_v} \cdot (lb/ld)^{2/3}) = 0.4369098$

with fc' ((12.3), ACI 440) = 37.12975

$fc = 33.00$

$fl = 1.3173$

$k = 1$

Effective FRP thickness, $tf = NL \cdot t \cdot \cos(b1) = 1.016$

efe ((12.5) and (12.7)) = 0.004

$fu = 0.01$

$Ef = 64828.00$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

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

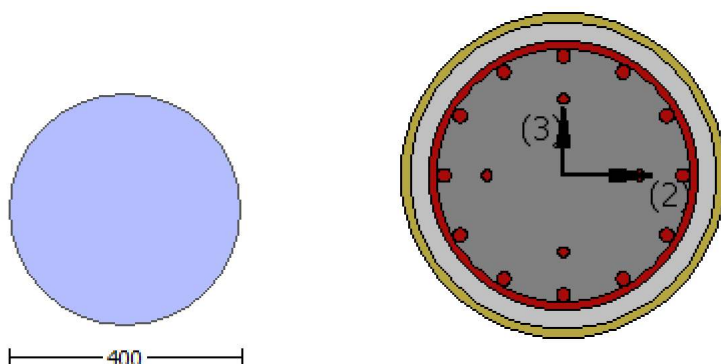
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $= 1.00$

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

Consequently:

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.56406
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $ε_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 8.8188366E-032$
 EDGE -B-
 Shear Force, $V_b = -8.8188366E-032$
 BOTH EDGES
 Axial Force, $F = -4821.109$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1223.127$
 -Compression: $A_{sl,com} = 1223.127$
 -Middle: $A_{sl,mid} = 1223.127$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.31871182$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 2.1596E+008$
 $\mu_{u1+} = 2.1596E+008$, 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
 $\mu_{u1-} = 2.1596E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 2.1596E+008$
 $\mu_{u2+} = 2.1596E+008$, 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
 $\mu_{u2-} = 2.1596E+008$, 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 μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$
 $= 0.9424778$

' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.30415227$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y * Min(1, 1.25 * (lb/d)^{2/3}) = 389.0139$

lb/d = 0.30

d1 = 44.00

R = 200.00

v = 0.00102726

N = 4821.109

Ac = 125663.706

$$= *Min(1, 1.25 * (lb/d)^{2/3}) = 0.30415227$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

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

$V_{Col0} = 451737.695$

$k_n l = 1$ (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).

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

$f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$$Mu = 1.1386922E-011$$

$$Vu = 8.8188366E-032$$

d = $0.8 * D = 320.00$

Nu = 4821.109

Ag = 125663.706

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

s = 100.00

V_s is multiplied by $Col = 0.00$

s/d = 0.3125

V_f ((11-3)-(11.4), ACI 440) = 194961.134

$f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe}((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d^2 / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = knl * V_{ColO}$
 $V_{ColO} = 451737.695$
 $knl = 1$ (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).

$\rho = 1$ (normal-weight concrete)
 $f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.1386922E-011$
 $\mu_v = 8.8188366E-032$
 $d = 0.8 * D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \rho_s * A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\rho_{col} = 0.00$
 $s/d = 0.3125$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe}((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d^2 / 4 = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $NoDir = 1$

Fiber orientations, $b_i = 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -5.3998017E-048$

EDGE -B-

Shear Force, $V_b = 5.3998017E-048$

BOTH EDGES

Axial Force, $F = -4821.109$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3669.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1223.127$

-Compression: $As_{l,com} = 1223.127$

-Middle: $As_{l,mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$

with

$M_{pr1} = \max(M_{u1+}, M_{u1-}) = 2.1596E+008$

$M_{u1+} = 2.1596E+008$, 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

Mu1- = 2.1596E+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
Mpr2 = Max(Mu2+ , Mu2-) = 2.1596E+008
Mu2+ = 2.1596E+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
Mu2- = 2.1596E+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 Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451737.695

Calculation of Shear Strength at edge 1, Vr1 = 451737.695
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO
VColO = 451737.695
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf

where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 194961.134

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

$b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$

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

$V_{\text{Col}0} = 451737.695$

$k_{nl} = 1$ (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)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 194961.134

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w \cdot d = \frac{V_s \cdot d}{4} = 80424.772$

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: 3
 Integration Section: (b)
 Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 0.03889518$
 Shear Force, $V_2 = 4539.895$
 Shear Force, $V_3 = 3.1724095E-013$
 Axial Force, $F = -4819.292$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{slt} = 0.00$
 -Compression: $A_{slc} = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1223.127$
 -Compression: $A_{sl,com} = 1223.127$
 -Middle: $A_{sl,mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $D_{bL} = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0 \cdot u = 0.00202168$
 $u = y + p = 0.00202168$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00202168$ ((4.29), Biskinis Phd))
 $M_y = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.0179E+013$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.292$
 $E_c \cdot I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 M_{y_ten} (8c) = 2.0578E+008
 $_{ten}$ (7c) = 69.48506
error of function (7c) = 0.00456662
 M_{y_com} (8d) = 5.0781E+008
 $_{com}$ (7d) = 68.37715
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 \cdot e_y \cdot (l_b / l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103288$
 $N = 4819.292$
 $A_c = 125663.706$
((10.1), ASCE 41-17) $= \min(, 1.25 \cdot (l_b / l_d)^{2/3}) = 0.4369098$
with $f_c' ((12.3), ACI 440) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = N \cdot L \cdot t \cdot \cos(b_1) = 1.016$
 e_{fe} ((12.5) and (12.7)) = 0.004
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

- Calculation of p -

From table 10-9: $p = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b / l_d \geq 1$
shear control ratio $V_y E / V_{col} E = 0.31871182$
 $d = 0.00$
 $s = 0.00$
 $t = 2 \cdot A_v / (d_c \cdot s) + 4 \cdot t_f / D \cdot (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, 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.
 $NUD = 4819.292$
 $Ag = 125663.706$
 $f_{cE} = 33.00$
 $f_{tE} = f_{yE} = 555.56$
 $pl = \text{Area_Tot_Long_Rein} / (Ag) = 0.0292$
 $f_{cE} = 33.00$

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

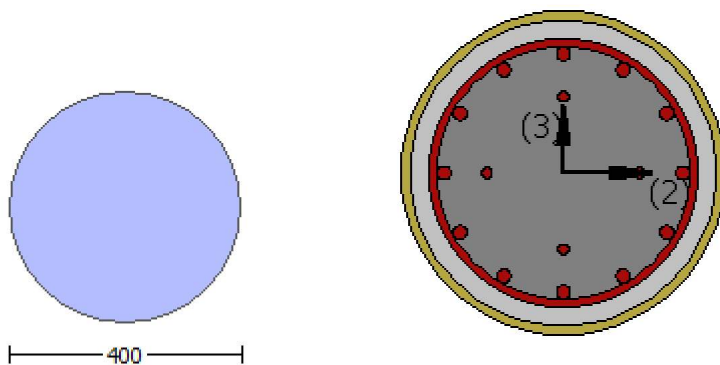
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.56$
 #####
 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $ef_u = 0.01$
 Number of directions, $NoDir = 1$
 Fiber orientations, $bi: 0.00^\circ$
 Number of layers, $NL = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -8.6091E+006$
 Shear Force, $V_a = -2868.587$
 EDGE -B-
 Bending Moment, $M_b = 0.02457639$
 Shear Force, $V_b = 2868.587$
 BOTH EDGES
 Axial Force, $F = -4819.961$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1426.283$
 -Compression: $As_c = 2243.097$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1223.127$
 -Compression: $As_{c,com} = 1223.127$
 -Middle: $As_{mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.20$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 330221.736$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 330221.736$
 $V_{CoI} = 330221.736$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.0113736$

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)
 $f'_c = 25.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$

$\mu = 8.6091E+006$
 $V_u = 2868.587$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4819.961$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe} ((11-5), \text{ACI } 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 267132.42$
 $b_w \cdot d = \frac{V_s \cdot d}{4} = 80424.772$

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 $\phi = 0.00023003$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.02022462$ ((4.29), Biskinis Phd))
 $M_y = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3001.156
 From table 10.5, ASCE 41-17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.0179E+013$
 $\text{factor} = 0.30$
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.961$
 $E_c \cdot I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038084E-006$
 $M_{y_ten} (8c) = 2.0578E+008$
 $\delta_{ten} (7c) = 69.48507$
 error of function (7c) = 0.00456648
 $M_{y_com} (8d) = 5.0781E+008$
 $\delta_{com} (7d) = 68.37715$
 error of function (7d) = -0.00101202
 with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 \cdot e_y \cdot (I_b / I_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d1 = 44.00$
 $R = 200.00$
 $v = 0.00103303$

$N = 4819.961$
 $A_c = 125663.706$
 $((10.1), ASCE 41-17) = \text{Min}(, 1.25 * ((lb/ld)^{2/3}) = 0.4369098$
 with $f_c^* ((12.3), ACI 440) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
 Effective FRP thickness, $t_f = NL * t * \text{Cos}(b1) = 1.016$
 $e_{fe} ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

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

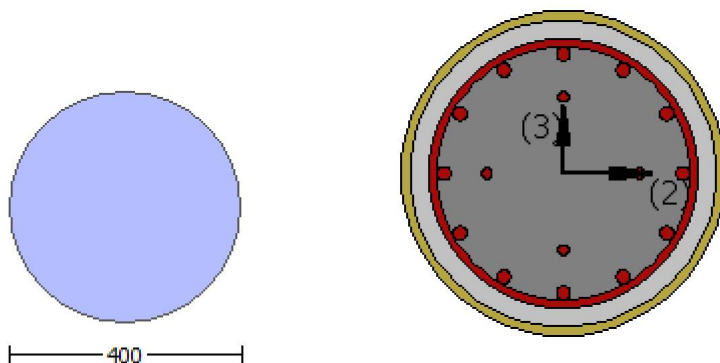
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_s = 1.25 \cdot f_{sm} = 694.45$
 #####
 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.56406
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 8.8188366E-032$
 EDGE -B-
 Shear Force, $V_b = -8.8188366E-032$
 BOTH EDGES
 Axial Force, $F = -4821.109$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1223.127$
 -Compression: $A_{sl,com} = 1223.127$
 -Middle: $A_{sl,mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.1596E+008$
 $\mu_{u1+} = 2.1596E+008$, 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
 $\mu_{u1-} = 2.1596E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.1596E+008$
 $\mu_{u2+} = 2.1596E+008$, 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

Mu2- = 2.1596E+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 Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TDY: fcc = fc* c = 51.61391

conf. factor c = 1.56406

fc = 33.00

From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139

$$lb/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

$$= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TDY: fcc = fc* c = 51.61391

conf. factor c = 1.56406

fc = 33.00

From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139

$$lb/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

$$= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451737.695

Calculation of Shear Strength at edge 1, Vr1 = 451737.695

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

VCol0 = 451737.695

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' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$
 $\mu_u = 1.1386922E-011$
 $\mu_v = 8.8188366E-032$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\phi_{col} = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), ACI 440) = 194961.134$
 $\phi = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \min(|V_f(45, \theta)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $\phi_{fe} = 0.004$, from (11.6a), ACI 440
 with $\phi_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{col} ((10.3), ASCE 41-17) = \phi_{col} \cdot V_{col0}$
 $V_{col0} = 451737.695$
 $\phi_{col} = 1$ (zero step-static loading)

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

$\phi_c = 1$ (normal-weight concrete)
 $f'_c = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.1386922E-011$
 $\mu_v = 8.8188366E-032$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\phi_{col} = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), ACI 440) = 194961.134$
 $\phi = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \min(|V_f(45, \theta)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe} ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $\phi_{fe} = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w d = \frac{A_s f_u}{4} = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
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, $f_s = 1.25 \cdot f_{sm} = 694.45$

Diameter, $D = 400.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.56406
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou, \min} = 0.30$
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $\epsilon_{fu} = 0.01$
Number of directions, $N_{Dir} = 1$
Fiber orientations, $b_i: 0.00^\circ$
Number of layers, $N_L = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -5.3998017E-048$
EDGE -B-
Shear Force, $V_b = 5.3998017E-048$
BOTH EDGES
Axial Force, $F = -4821.109$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl} = 0.00$
-Compression: $A_{slc} = 3669.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl, \text{ten}} = 1223.127$

-Compression: $A_s l_{com} = 1223.127$
-Middle: $A_s l_{mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.1596E+008$

$M_{u1+} = 2.1596E+008$, 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

$M_{u1-} = 2.1596E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.1596E+008$

$M_{u2+} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.1596E+008$

$\phi = 0.9424778$

$\lambda = 0.8362801$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

$= \phi \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.1596E+008$

$\phi = 0.9424778$

$\lambda = 0.8362801$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

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

$V_{\text{ColO}} = 451737.695$

$k_{nl} = 1$ (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)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129\text{E-}012$

$V_u = 5.3998017\text{E-}048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 194961.134$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation θ_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

$f_{fe} ((11-5), \text{ACI } 440) = 259.312$

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

$b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$

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

$V_{\text{ColO}} = 451737.695$

$k_{nl} = 1$ (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)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129\text{E-}012$

$V_u = 5.3998017\text{E-}048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 0.3125$
 $V_f((11-3)-(11.4), \text{ACI } 440) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = NL * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe}((11-5), \text{ACI } 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w * d = \text{Col} * d / 4 = 80424.772$

 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 Number of directions, $\text{NoDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $NL = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 5.7912052E-010$
 Shear Force, $V2 = -2868.587$
 Shear Force, $V3 = -2.0045250E-013$
 Axial Force, $F = -4819.961$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1426.283$
 -Compression: $As_c = 2243.097$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1223.127$
 -Compression: $As_{c,com} = 1223.127$
 -Middle: $As_{mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $Db_L = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.04010842$
 $u = y + p = 0.04010842$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.01010842$ ((4.29), Biskinis Phd))
 $My = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.0179E+013$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.961$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment My

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

$My = \min(My_{ten}, My_{com}) = 2.0578E+008$
 $y = 9.1038084E-006$
 $My_{ten} (8c) = 2.0578E+008$
 $_{ten} (7c) = 69.48507$
 error of function (7c) = 0.00456648
 $My_{com} (8d) = 5.0781E+008$
 $_{com} (7d) = 68.37715$
 error of function (7d) = -0.00101202
 with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103303$
 $N = 4819.961$
 $A_c = 125663.706$
 ((10.1), ASCE 41-17) $= \min(, 1.25 * (l_b / l_d)^{2/3}) = 0.4369098$
 with $f_c' ((12.3), ACI 440) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
 Effective FRP thickness, $t_f = NL * t * \cos(b_1) = 1.016$
 $e_f ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of p -

From table 10-9: $p = 0.03$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
shear control ratio $V_y E / V_{col} E = 0.31871182$

$$d = 0.00$$

$$s = 0.00$$

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

$A_v = 78.53982$, 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.

$$N_{UD} = 4819.961$$

$$A_g = 125663.706$$

$$f_{cE} = 33.00$$

$$f_{ytE} = f_{ylE} = 555.56$$

$$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0292$$

$$f_{cE} = 33.00$$

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

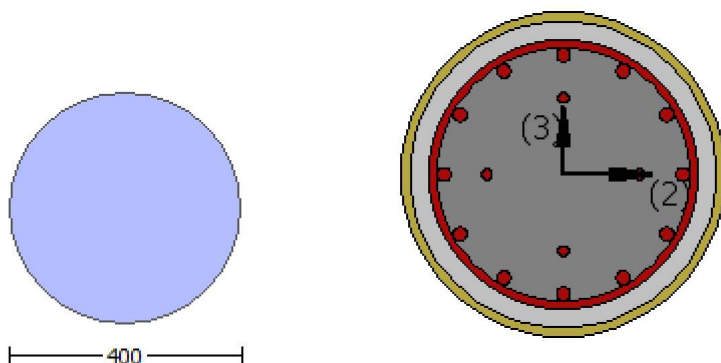
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $e_{fu} = 0.01$

Number of directions, $NoDir = 1$

Fiber orientations, $bi: 0.00^\circ$

Number of layers, $NL = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 5.7912052E-010$

Shear Force, $V_a = -2.0045250E-013$

EDGE -B-

Bending Moment, $M_b = 2.2473986E-011$

Shear Force, $V_b = 2.0045250E-013$

BOTH EDGES

Axial Force, $F = -4819.961$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1426.283$

-Compression: $As_c = 2243.097$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 1223.127$

-Compression: $As_{l,com} = 1223.127$

-Middle: $As_{l,mid} = 1223.127$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.20$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 393311.051$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 393311.051$

$V_{CoI} = 393311.051$

$k_n = 1.00$

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)

$f'_c = 25.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 5.7912052E-010$

$\mu_v = 2.0045250E-013$

$d = 0.8 \cdot D = 320.00$

$N_u = 4819.961$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 197392.088$

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

$f_y = 500.00$

$s = 100.00$

V_s is multiplied by $CoI = 0.00$

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 194961.134

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,

where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_{fe} = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 267132.42$

$b_w \cdot d = \sqrt{2} \cdot d^2 / 4 = 80424.772$

displacement_ductility_demand is calculated as γ / y

- Calculation of γ / y for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta = 1.6445157E-020$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.01010842$ ((4.29), Biskinis Phd))

$M_y = 2.0578E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.0179E+013$

factor = 0.30

$A_g = 125663.706$

$f'_c = 33.00$

$N = 4819.961$

$E_c \cdot I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.0578E+008$

$y = 9.1038084E-006$
 $M_{y_ten} (8c) = 2.0578E+008$
 $_{ten} (7c) = 69.48507$
error of function (7c) = 0.00456648
 $M_{y_com} (8d) = 5.0781E+008$
 $_{com} (7d) = 68.37715$
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103303$
 $N = 4819.961$
 $A_c = 125663.706$
((10.1), ASCE 41-17) $= \text{Min}(, 1.25 * (l_b / l_d)^{2/3}) = 0.4369098$
with f_c^* ((12.3), ACI 440) = 37.12975
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = N L * t * \text{Cos}(b_1) = 1.016$
 e_{fe} ((12.5) and (12.7)) = 0.004
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

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

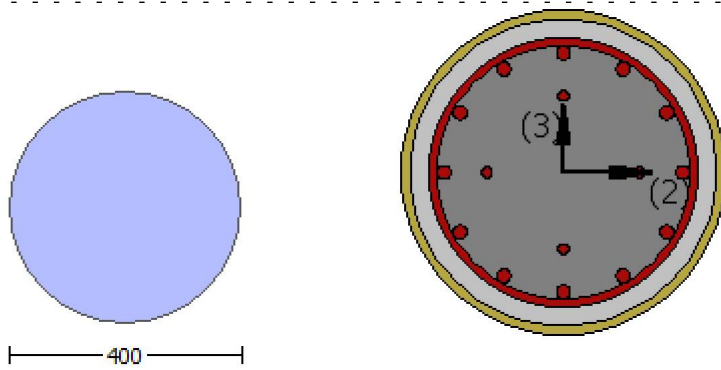
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 8.8188366E-032$

EDGE -B-

Shear Force, $V_b = -8.8188366E-032$

BOTH EDGES

Axial Force, $F = -4821.109$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $Aslt = 0.00$
 -Compression: $Aslc = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl,ten = 1223.127$
 -Compression: $Asl,com = 1223.127$
 -Middle: $Asl,mid = 1223.127$

Calculation of Shear Capacity ratio , $Ve/Vr = 0.31871182$
 Member Controlled by Flexure ($Ve/Vr < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $Ve = (Mpr1 + Mpr2)/ln = 143974.143$
 with
 $Mpr1 = \text{Max}(Mu1+ , Mu1-) = 2.1596E+008$
 $Mu1+ = 2.1596E+008$, 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
 $Mu1- = 2.1596E+008$, 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
 $Mpr2 = \text{Max}(Mu2+ , Mu2-) = 2.1596E+008$
 $Mu2+ = 2.1596E+008$, 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
 $Mu2- = 2.1596E+008$, 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 $Mu1+$

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
 $Mu = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TBDY: $fcc = fc^* c = 51.61391$
 conf. factor $c = 1.56406$
 $fc = 33.00$
 From 10.3.5, ASCE41-17, Final value of $f_y: f_y * \text{Min}(1, 1.25 * (lb/d)^{2/3}) = 389.0139$
 $lb/d = 0.30$
 $d1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $Ac = 125663.706$
 $= * \text{Min}(1, 1.25 * (lb/d)^{2/3}) = 0.30415227$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of $Mu1-$

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
 $Mu = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TBDY: $fcc = fc^* c = 51.61391$
 conf. factor $c = 1.56406$

$f_c = 33.00$
 From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
 conf. factor $c = 1.56406$
 $f_c = 33.00$
 From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
 error of function (3.68), Biskinis Phd = 53851.649
 From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
 conf. factor $c = 1.56406$
 $f_c = 33.00$
 From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

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

$V_{\text{ColO}} = 451737.695$

$k_n l = 1$ (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)

$f'_c = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 1.1386922\text{E-}011$

$V_u = 8.8188366\text{E-}032$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 194961.134$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

$b_w \cdot d = \sqrt{2} \cdot d \cdot d / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$

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

$V_{\text{ColO}} = 451737.695$

$k_n l = 1$ (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)

$f'_c = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 1.1386922\text{E-}011$

$V_u = 8.8188366\text{E-}032$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \frac{1}{2} A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L * t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe} ((11-5), \text{ACI } 440) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w * d = \frac{1}{4} * d * d = 80424.772$

 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_s = 1.25 * f_{sm} = 694.45$
 #####
 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.56406
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou, \min} = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$
Number of directions, $NoDir = 1$
Fiber orientations, $bi = 0.00^\circ$
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -5.3998017E-048$
EDGE -B-
Shear Force, $V_b = 5.3998017E-048$
BOTH EDGES
Axial Force, $F = -4821.109$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3669.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1223.127$
-Compression: $As_{c,com} = 1223.127$
-Middle: $As_{mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.1596E+008$
 $\mu_{u1+} = 2.1596E+008$, 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
 $\mu_{u1-} = 2.1596E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.1596E+008$
 $\mu_{u2+} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$

$\phi = 0.9424778$
 $\phi' = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \min(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $\phi' \cdot \min(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{1-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.1596E+008$

$= 0.9424778$
 $' = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c' \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$
 $V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Col0}$
 $V_{Col0} = 451737.695$
 $k_{nl} = 1$ (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)
 $f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 4.3208129E-012$
 $V_u = 5.3998017E-048$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \frac{1}{2} \cdot A_{\text{stirrup}} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 $V_f \text{ ((11-3)-(11.4), ACI 440)} = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(\theta, a_i)$, is implemented for every different fiber orientation a_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe} \text{ ((11-5), ACI 440)} = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w \cdot d = \cdot d \cdot d/4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$

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

$V_{Col0} = 451737.695$

$k_{nl} = 1$ (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).

$= 1$ (normal-weight concrete)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$\nu_u = 5.3998017E-048$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

V_s is multiplied by $Col = 0.00$

$s/d = 0.3125$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 194961.134$

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,

where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta, a)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = \theta_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L * t / N_{oDir} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

$f_{fe} \text{ ((11-5), ACI 440)} = 259.312$

$E_f = 64828.00$

$f_{fe} = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

$b_w * d = \frac{1}{4} * d * d = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i = 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = -8.6091E+006$
 Shear Force, $V_2 = -2868.587$
 Shear Force, $V_3 = -2.0045250E-013$
 Axial Force, $F = -4819.961$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 1426.283$
 -Compression: $A_{sc} = 2243.097$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1223.127$
 -Compression: $A_{sc,com} = 1223.127$
 -Middle: $A_{st,mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $D_{bL} = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.05022462$
 $u = y + p = 0.05022462$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.02022462$ ((4.29), Biskinis Phd))
 $M_y = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3001.156
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.0179E+013$
 factor = 0.30
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.961$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038084E-006$
 $M_{y_ten} (8c) = 2.0578E+008$
 $_{ten} (7c) = 69.48507$
 error of function (7c) = 0.00456648
 $M_{y_com} (8d) = 5.0781E+008$
 $_{com} (7d) = 68.37715$
 error of function (7d) = -0.00101202

with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b/l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103303$
 $N = 4819.961$
 $A_c = 125663.706$
 ((10.1), ASCE 41-17) $= \text{Min}(, 1.25 * (l_b/l_d)^{2/3}) = 0.4369098$
 with $f_c^* ((12.3), \text{ACI 440}) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
 Effective FRP thickness, $t_f = N L * t * \cos(b_1) = 1.016$
 $e_{fe} ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 - Calculation of p -

 From table 10-9: $p = 0.03$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_y E / V_{colOE} = 0.31871182$

$d = 0.00$

$s = 0.00$

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

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

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

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.

$N_{UD} = 4819.961$

$A_g = 125663.706$

$f_{cE} = 33.00$

$f_{ytE} = f_{yIE} = 555.56$

$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0292$

$f_{cE} = 33.00$

 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

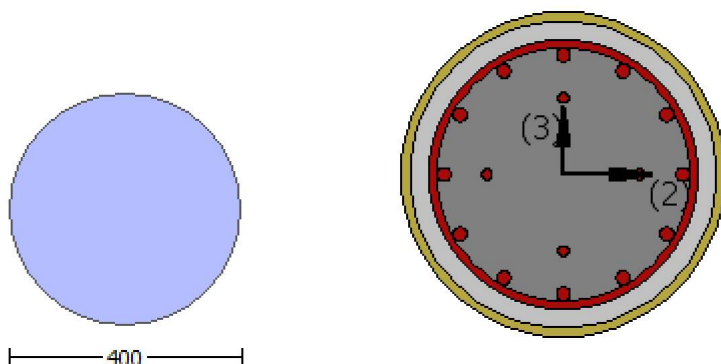
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $NoDir = 1$

Fiber orientations, θ_i : 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, M_a = -8.6091E+006
Shear Force, V_a = -2868.587
EDGE -B-
Bending Moment, M_b = 0.02457639
Shear Force, V_b = 2868.587
BOTH EDGES
Axial Force, F = -4819.961
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: A_{st} = 0.00
-Compression: A_{sc} = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten}$ = 1223.127
-Compression: $A_{sc,com}$ = 1223.127
-Middle: $A_{sc,mid}$ = 1223.127
Mean Diameter of Tension Reinforcement, $D_{bL,ten}$ = 17.20

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 393311.051$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 393311.051$
 $V_{CoI} = 393311.051$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.06274869$

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 = 25.00, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.02457639$
 $V_u = 2868.587$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4819.961$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = \frac{1}{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
total thickness per orientation, $t_{f1} = NL \cdot t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 267132.42$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 80424.772$

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 $\theta = 0.00012686$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00202168$ ((4.29), Biskinis Phd))
 $M_y = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.0179E+013$
factor = 0.30
Ag = 125663.706
fc' = 33.00
N = 4819.961
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038084E-006$
 $M_{y_ten} (8c) = 2.0578E+008$
 $\phi_{ten} (7c) = 69.48507$
error of function (7c) = 0.00456648
 $M_{y_com} (8d) = 5.0781E+008$
 $\phi_{com} (7d) = 68.37715$
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00103303
N = 4819.961
Ac = 125663.706
((10.1), ASCE 41-17) $\phi = \min(\phi, 1.25 * \phi * (I_b / I_d)^{2/3}) = 0.4369098$
with fc' ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
k = 1
Effective FRP thickness, $t_f = N L * t * \cos(b1) = 1.016$
efe ((12.5) and (12.7)) = 0.004
fu = 0.01
Ef = 64828.00

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

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

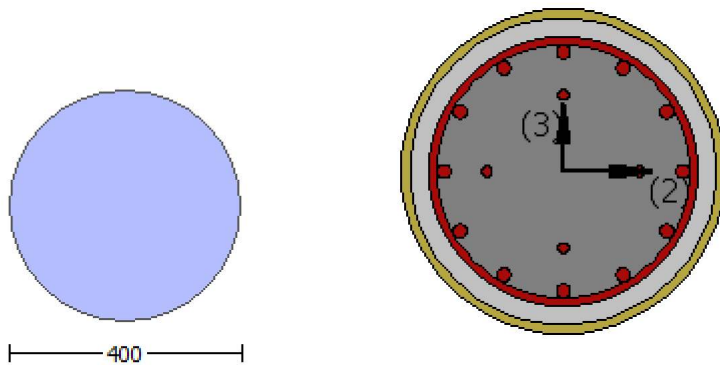
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\phi = 1.00$

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

Consequently:

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$
Tensile Strength, $f_{fu} = 1055.00$
Tensile Modulus, $E_f = 64828.00$
Elongation, $e_{fu} = 0.01$
Number of directions, $NoDir = 1$
Fiber orientations, $bi = 0.00^\circ$
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 8.8188366E-032$
EDGE -B-
Shear Force, $V_b = -8.8188366E-032$
BOTH EDGES
Axial Force, $F = -4821.109$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3669.38$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1223.127$
-Compression: $As_{l,com} = 1223.127$
-Middle: $As_{l,mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.1596E+008$
 $\mu_{u1+} = 2.1596E+008$, 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
 $\mu_{u1-} = 2.1596E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.1596E+008$
 $\mu_{u2+} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$

$\beta_1 = 0.9424778$
 $\beta_1 = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TDY: $f_{cc} = f_c^* \quad c = 51.61391$
conf. factor $\gamma_c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y * \min(1, 1.25 * (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $\gamma_c = \gamma_c * \min(1, 1.25 * (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2-}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), M_u
 $M_u = 2.1596E+008$

$\lambda = 0.9424778$
 $\lambda' = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c' \cdot \lambda = 51.61391$
conf. factor $\lambda = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $\lambda = \lambda' \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

$V_{r1} = V_{CoI}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{CoI0}$

$V_{CoI0} = 451737.695$

$k_{nl} = 1$ (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).

$\lambda = 1$ (normal-weight concrete)
 $f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 1.1386922E-011$
 $V_u = 8.8188366E-032$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \lambda / 2 \cdot A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\lambda_{CoI} = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \cot \alpha) \sin \alpha$ which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(\theta, \alpha)$, is implemented for every different fiber orientation α_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \alpha_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L \cdot t / N_{oDir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w d = \frac{A_s f_y}{4} = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n V_{Col0}$
 $V_{Col0} = 451737.695$
 $k_n = 1$ (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)
 $f'_c = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa ((22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.1386922E-011$
 $\nu_u = 8.8188366E-032$
 $d = 0.8D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From ((11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \frac{1}{2} A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\lambda_{Col} = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
In ((11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression,
where a is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i ,
as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $\theta_1 = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $t_{f1} = N_L t / N_{Dir} = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from ((11.6a), ACI 440
with $f_u = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w d = \frac{A_s f_y}{4} = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -5.3998017E-048$

EDGE -B-

Shear Force, $V_b = 5.3998017E-048$

BOTH EDGES

Axial Force, $F = -4821.109$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3669.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1223.127$

-Compression: $As_{c,com} = 1223.127$

-Middle: $As_{l,mid} = 1223.127$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.31871182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.1596E+008$

$Mu_{1+} = 2.1596E+008$, 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

$Mu_{1-} = 2.1596E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.1596E+008$

$Mu_{2+} = 2.1596E+008$, 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

$Mu_{2-} = 2.1596E+008$, 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 Mu_{1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_2 -

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

$$\mu = 2.1596 \times 10^8$$

$$= 0.9424778$$

$$' = 0.8362801$$

error of function (3.68), Biskinis Phd = 53851.649

From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$

$$\text{conf. factor } c = 1.56406$$

$$f_c = 33.00$$

From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

$$= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

$$V_{r1} = V_{co1} \text{ ((10.3), ASCE 41-17)} = k_n l \cdot V_{co10}$$

$$V_{co10} = 451737.695$$

$$k_n l = 1 \text{ (zero step-static loading)}$$

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).

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

$$f_c' = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$\mu = 4.3208129 \times 10^{-12}$$

$$V_u = 5.3998017 \times 10^{-48}$$

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

$$N_u = 4821.109$$

$$A_g = 125663.706$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 219326.297$$

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

$$f_y = 555.56$$

$s = 100.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), ACI 440) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
where a is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(,)$, is implemented for every different fiber orientation a_i ,
as well as for 2 crack directions, $a = 45^\circ$ and $a = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $a_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $tf_1 = NL * t / NoDir = 1.016$
 $df_v = d$ (figure 11.2, ACI 440) = 370.00
 $ffe ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
with $fu = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $bw * d = s * d * d / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$
 $V_{ColO} = 451737.695$
 $knl = 1$ (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)
 $f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 4.3208129E-012$
 $\mu_v = 5.3998017E-048$
 $d = 0.8 * D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \lambda / 2 * A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 0.3125$
 $V_f ((11-3)-(11.4), ACI 440) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
where a is the angle of the crack direction (see KANEPE).
This later relation, considered as a function $V_f(,)$, is implemented for every different fiber orientation a_i ,
as well as for 2 crack directions, $a = 45^\circ$ and $a = -45^\circ$ to take into consideration the cyclic seismic loading.
orientation 1: $a_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, a_1)|)$, with:
total thickness per orientation, $tf_1 = NL * t / NoDir = 1.016$
 $df_v = d$ (figure 11.2, ACI 440) = 370.00
 $ffe ((11-5), ACI 440) = 259.312$
 $E_f = 64828.00$
 $fe = 0.004$, from (11.6a), ACI 440
with $fu = 0.01$
From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $bw * d = s * d * d / 4 = 80424.772$

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, $\gamma = 1.00$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 2.2473986E-011$

Shear Force, $V_2 = 2868.587$

Shear Force, $V_3 = 2.0045250E-013$

Axial Force, $F = -4819.961$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 3669.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1223.127$

-Compression: $A_{sl,com} = 1223.127$

-Middle: $A_{sl,mid} = 1223.127$

Mean Diameter of Tension Reinforcement, $Db_L = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.04010842$

$u = y + p = 0.04010842$

- Calculation of y -

$y = (M \gamma L_s / 3) / E_{eff} = 0.01010842 ((4.29), \text{Biskinis Phd})$

$M \gamma = 2.0578E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.0179E+013$

factor = 0.30
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.961$
 $E_c I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $\gamma = 9.1038084E-006$
 $M_{y_ten} (8c) = 2.0578E+008$
 $\gamma_{ten} (7c) = 69.48507$
error of function (7c) = 0.00456648
 $M_{y_com} (8d) = 5.0781E+008$
 $\gamma_{com} (7d) = 68.37715$
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) $\gamma_y = \min(\gamma_y, 1.25 \cdot \gamma_y \cdot (I_b/I_d)^{2/3}) = 0.0027778$
 $\epsilon_{co} = 0.002$
 $\alpha_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103303$
 $N = 4819.961$
 $A_c = 125663.706$
((10.1), ASCE 41-17) $\gamma = \min(\gamma, 1.25 \cdot \gamma \cdot (I_b/I_d)^{2/3}) = 0.4369098$
with $f_c' ((12.3), ACI 440) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = N L \cdot t \cdot \cos(b_1) = 1.016$
 $\epsilon_{fe} ((12.5) \text{ and } (12.7)) = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

- Calculation of p -

From table 10-9: $p = 0.03$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$

shear control ratio $V_y E / V_{col} O E = 0.31871182$

$d = 0.00$

$s = 0.00$

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

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

$d_c = D - 2 \cdot \text{cover}$ - 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.

$N_{UD} = 4819.961$

$A_g = 125663.706$

$f_{cE} = 33.00$

$f_{ytE} = f_{ylE} = 555.56$

$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0292$

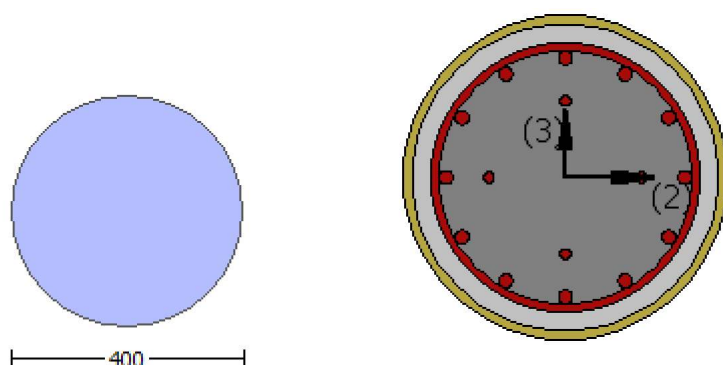
$f_{cE} = 33.00$

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: Life Safety (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 Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Element Length, L = 3000.00
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, t = 1.016
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 Number of directions, NoDir = 1
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, NL = 1
 Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = 5.7912052E-010$
 Shear Force, $V_a = -2.0045250E-013$
 EDGE -B-
 Bending Moment, $M_b = 2.2473986E-011$
 Shear Force, $V_b = 2.0045250E-013$
 BOTH EDGES
 Axial Force, F = -4819.961
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1223.127$
 -Compression: $A_{st,com} = 1223.127$
 -Middle: $A_{st,mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 17.20$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 393311.051$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoIO} = 393311.051$
 $V_{CoI} = 393311.051$
 $k_n = 1.00$
 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)
 $f_c' = 25.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 2.00$
 $M_u = 2.2473986E-011$
 $V_u = 2.0045250E-013$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4819.961$
 $A_g = 125663.706$
 From ((11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = /2 \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_s is multiplied by $CoI = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), ACI 440) = 194961.134
 $f = 0.95$, for fully-wrapped sections

$wf/sf = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $Vf(\theta, a)$, is implemented for every different fiber orientation a , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = b1 + 90^\circ = 90.00$

$Vf = \text{Min}(|Vf(45, \theta)|, |Vf(-45, a1)|)$, with:

total thickness per orientation, $tf1 = NL * t / \text{NoDir} = 1.016$

$dfv = d$ (figure 11.2, ACI 440) = 370.00

ffe ((11-5), ACI 440) = 259.312

$Ef = 64828.00$

$fe = 0.004$, from (11.6a), ACI 440

with $fu = 0.01$

From (11-11), ACI 440: $Vs + Vf \leq 267132.42$

$bw * d = \rho_s * d^2 / 4 = 80424.772$

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 $\theta = 7.4566431E-021$

$y = (My * Ls / 3) / Eleff = 0.01010842$ ((4.29), Biskinis Phd))

$My = 2.0578E+008$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $Eleff = \text{factor} * Ec * Ig = 1.0179E+013$

factor = 0.30

$Ag = 125663.706$

$fc' = 33.00$

$N = 4819.961$

$Ec * Ig = 3.3929E+013$

Calculation of Yielding Moment My

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

$My = \text{Min}(My_{ten}, My_{com}) = 2.0578E+008$

$y = 9.1038084E-006$

My_{ten} (8c) = 2.0578E+008

$_{ten}$ (7c) = 69.48507

error of function (7c) = 0.00456648

My_{com} (8d) = 5.0781E+008

$_{com}$ (7d) = 68.37715

error of function (7d) = -0.00101202

with ((10.1), ASCE 41-17) $ey = \text{Min}(ey, 1.25 * ey * (lb / ld)^{2/3}) = 0.0027778$

$eco = 0.002$

$apl = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)

$d1 = 44.00$

$R = 200.00$

$v = 0.00103303$

$N = 4819.961$

$Ac = 125663.706$

((10.1), ASCE 41-17) $= \text{Min}(\rho_s, 1.25 * \rho_s * (lb / ld)^{2/3}) = 0.4369098$

with fc' ((12.3), ACI 440) = 37.12975

$fc = 33.00$

$fl = 1.3173$

$k = 1$

Effective FRP thickness, $tf = NL * t * \text{Cos}(b1) = 1.016$

efe ((12.5) and (12.7)) = 0.004

$fu = 0.01$

$Ef = 64828.00$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

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

At local axis: 3

Integration Section: (b)

Calculation No. 16

column C1, Floor 1

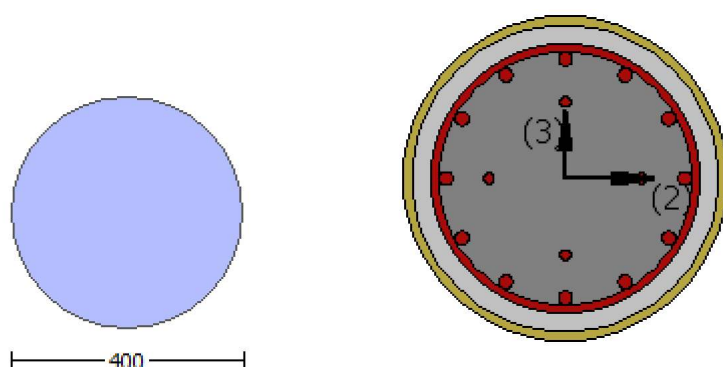
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.56406
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $ε_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 8.8188366E-032$
 EDGE -B-
 Shear Force, $V_b = -8.8188366E-032$
 BOTH EDGES
 Axial Force, $F = -4821.109$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1223.127$
 -Compression: $A_{sl,com} = 1223.127$
 -Middle: $A_{sl,mid} = 1223.127$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.31871182$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 2.1596E+008$
 $\mu_{u1+} = 2.1596E+008$, 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
 $\mu_{u1-} = 2.1596E+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 2.1596E+008$
 $\mu_{u2+} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 2.1596E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ_u
 $\mu_u = 2.1596E+008$
 $= 0.9424778$

' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_1 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $= \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_2 +

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596E+008$

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c \cdot c = 51.61391$
conf. factor $c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$

$$\begin{aligned}
 v &= 0.00102726 \\
 N &= 4821.109 \\
 A_c &= 125663.706 \\
 &= * \text{Min}(1, 1.25 * (l_b / d)^{2/3}) = 0.30415227
 \end{aligned}$$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

Calculation of μ_2 -

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), μ
 $\mu = 2.1596 \text{E} + 008$

$$\begin{aligned}
 &= 0.9424778 \\
 ' &= 0.8362801 \\
 \text{error of function (3.68), Biskinis Phd} &= 53851.649 \\
 \text{From 5A.2, TBDY: } f_{cc} &= f_c' \cdot c = 51.61391 \\
 \text{conf. factor } c &= 1.56406 \\
 f_c &= 33.00 \\
 \text{From 10.3.5, ASCE41-17, Final value of } f_y &: f_y * \text{Min}(1, 1.25 * (l_b / d)^{2/3}) = 389.0139 \\
 l_b / d &= 0.30 \\
 d_1 &= 44.00 \\
 R &= 200.00 \\
 v &= 0.00102726 \\
 N &= 4821.109 \\
 A_c &= 125663.706 \\
 &= * \text{Min}(1, 1.25 * (l_b / d)^{2/3}) = 0.30415227
 \end{aligned}$$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 451737.695$

Calculation of Shear Strength at edge 1, $V_{r1} = 451737.695$

$V_{r1} = V_{CoI0}$ ((10.3), ASCE 41-17) = $k_n l * V_{CoI0}$

$V_{CoI0} = 451737.695$

$k_n l = 1$ (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).

$$\begin{aligned}
 &= 1 \text{ (normal-weight concrete)} \\
 f_c' &= 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)} \\
 M / V d &= 2.00 \\
 \mu_u &= 1.1386922 \text{E} - 011 \\
 \mu_v &= 8.8188366 \text{E} - 032 \\
 d &= 0.8 * D = 320.00 \\
 N_u &= 4821.109 \\
 A_g &= 125663.706 \\
 \text{From (11.5.4.8), ACI 318-14: } V_s &= 219326.297 \\
 A_v &= / 2 * A_{\text{stirrup}} = 123370.055 \\
 f_y &= 555.56 \\
 s &= 100.00 \\
 V_s \text{ is multiplied by } C_{ol} &= 0.00 \\
 s / d &= 0.3125 \\
 V_f \text{ ((11-3)-(11.4), ACI 440)} &= 194961.134
 \end{aligned}$$

$f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe}((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d^2 / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col}((10.3), \text{ASCE 41-17}) = knl * V_{Col0}$
 $V_{Col0} = 451737.695$
 $knl = 1$ (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).

$\rho = 1$ (normal-weight concrete)
 $f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M / Vd = 2.00$
 $\mu_u = 1.1386922E-011$
 $\mu_v = 8.8188366E-032$
 $d = 0.8 * D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \rho_s * A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 V_s is multiplied by $\rho_{col} = 0.00$
 $s/d = 0.3125$
 $V_f((11-3)-(11.4), \text{ACI 440}) = 194961.134$
 $f = 0.95$, for fully-wrapped sections
 $wf/sf = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a)\sin a$ which is more a generalised expression,
 where a is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i ,
 as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 $f_{fe}((11-5), \text{ACI 440}) = 259.312$
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d^2 / 4 = 80424.772$

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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

Diameter, $D = 400.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.56406

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

FRP Wrapping Data

Type: Carbon

Cured laminate properties (design values)

Thickness, $t = 1.016$

Tensile Strength, $f_{fu} = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $\epsilon_{fu} = 0.01$

Number of directions, $N_{oDir} = 1$

Fiber orientations, $b_i: 0.00^\circ$

Number of layers, $N_L = 1$

Radius of rounding corners, $R = 40.00$

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -5.3998017E-048$

EDGE -B-

Shear Force, $V_b = 5.3998017E-048$

BOTH EDGES

Axial Force, $F = -4821.109$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 3669.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1223.127$

-Compression: $A_{sl,com} = 1223.127$

-Middle: $A_{sl,mid} = 1223.127$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31871182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 143974.143$

with

$M_{pr1} = \max(M_{u1+}, M_{u1-}) = 2.1596E+008$

$M_{u1+} = 2.1596E+008$, 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

Mu1- = 2.1596E+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
Mpr2 = Max(Mu2+ , Mu2-) = 2.1596E+008
Mu2+ = 2.1596E+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
Mu2- = 2.1596E+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 Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008

= 0.9424778
' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc* c = 51.61391
conf. factor c = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/d)^ 2/3) = 389.0139
lb/d = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
= *Min(1,1.25*(lb/d)^ 2/3) = 0.30415227

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451737.695

Calculation of Shear Strength at edge 1, Vr1 = 451737.695
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO
VColO = 451737.695
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*VF'

where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 194961.134

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00

f_{fe} ((11-5), ACI 440) = 259.312

$E_f = 64828.00$

$f_e = 0.004$, from (11.6a), ACI 440

with $f_u = 0.01$

From (11-11), ACI 440: $V_s + V_f \leq 306911.784$

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

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$

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

$V_{\text{Col}0} = 451737.695$

$k_{nl} = 1$ (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)

$f'_c = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

From (11.5.4.8), ACI 318-14: $V_s = 219326.297$

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

V_f ((11-3)-(11.4), ACI 440) = 194961.134

$f = 0.95$, for fully-wrapped sections

$w_f/s_f = 1$ (FRP strips adjacent to one another).

In (11.3) $\sin + \cos$ is replaced with $(\cot + \cot a) \sin a$ which is more a generalised expression, where a is the angle of the crack direction (see KANEPE).

This later relation, considered as a function $V_f(\theta)$, is implemented for every different fiber orientation a_i , as well as for 2 crack directions, $\theta = 45^\circ$ and $\theta = -45^\circ$ to take into consideration the cyclic seismic loading.

orientation 1: $\theta = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a_1)|)$, with:

total thickness per orientation, $t_{f1} = N_L \cdot t / N_{\text{Dir}} = 1.016$

$d_{fv} = d$ (figure 11.2, ACI 440) = 370.00
 f_{fe} ((11-5), ACI 440) = 259.312
 $E_f = 64828.00$
 $f_e = 0.004$, from (11.6a), ACI 440
 with $f_u = 0.01$
 From (11-11), ACI 440: $V_s + V_f \leq 306911.784$
 $b_w \cdot d = \frac{V_s \cdot d}{4} = 80424.772$

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: 3
 Integration Section: (b)
 Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 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 Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Diameter, $D = 400.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 FRP Wrapping Data
 Type: Carbon
 Cured laminate properties (design values)
 Thickness, $t = 1.016$
 Tensile Strength, $f_{fu} = 1055.00$
 Tensile Modulus, $E_f = 64828.00$
 Elongation, $\epsilon_{fu} = 0.01$
 Number of directions, $N_{oDir} = 1$
 Fiber orientations, $b_i: 0.00^\circ$
 Number of layers, $N_L = 1$
 Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 0.02457639$
 Shear Force, $V_2 = 2868.587$
 Shear Force, $V_3 = 2.0045250E-013$
 Axial Force, $F = -4819.961$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{slt} = 0.00$
 -Compression: $A_{slc} = 3669.38$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1223.127$
 -Compression: $A_{sl,com} = 1223.127$
 -Middle: $A_{sl,mid} = 1223.127$
 Mean Diameter of Tension Reinforcement, $D_{bL} = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0 \cdot u = 0.03202168$
 $u = y + p = 0.03202168$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00202168$ ((4.29), Biskinis Phd))
 $M_y = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.0179E+013$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.961$
 $E_c \cdot I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \min(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038084E-006$
 M_{y_ten} (8c) = 2.0578E+008
 $_{ten}$ (7c) = 69.48507
error of function (7c) = 0.00456648
 M_{y_com} (8d) = 5.0781E+008
 $_{com}$ (7d) = 68.37715
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) $e_y = \min(e_y, 1.25 \cdot e_y \cdot (l_b / l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103303$
 $N = 4819.961$
 $A_c = 125663.706$
((10.1), ASCE 41-17) $= \min(, 1.25 \cdot (l_b / l_d)^{2/3}) = 0.4369098$
with $f_c' ((12.3), ACI 440) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = N \cdot L \cdot t \cdot \cos(b_1) = 1.016$
 e_{fe} ((12.5) and (12.7)) = 0.004
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

- Calculation of p -

From table 10-9: $p = 0.03$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b / l_d \geq 1$
shear control ratio $V_y E / V_{col} E = 0.31871182$
 $d = 0.00$
 $s = 0.00$
 $t = 2 \cdot A_v / (d_c \cdot s) + 4 \cdot t_f / D \cdot (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, 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.

$N_{UD} = 4819.961$

$A_g = 125663.706$

$f_{cE} = 33.00$

$f_{ytE} = f_{ylE} = 555.56$

$p_l = \text{Area_Tot_Long_Rein} / (A_g) = 0.0292$

$f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (b)
