

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

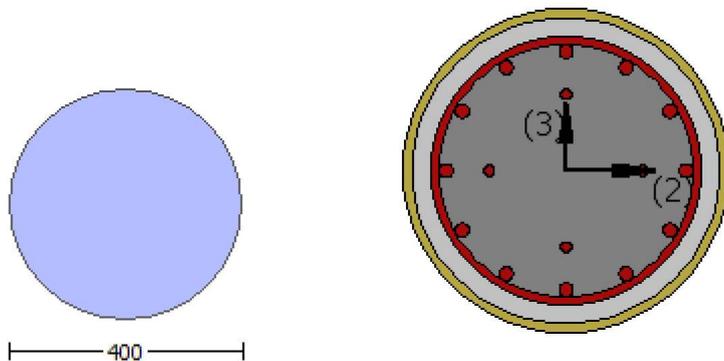
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 $l_o/l_{o,min} = l_b/l_d = 0.30$

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, $NoDir = 1$

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: $A_{sl,t} = 1426.283$

-Compression: $A_{sl,c} = 2243.097$

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, $Db_{L,ten} = 17.20$

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) = $knI \cdot V_{CoIO} = 330221.669$

$V_{CoI} = 330221.669$

$knI = 1.00$

$displacement_ductility_demand = 0.01800015$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' 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)

$M/Vd = 4.00$

$M_u = 1.3625E+007$

$V_u = 4539.895$

$d = 0.8 \cdot D = 320.00$

$N_u = 4819.292$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = \frac{1}{2} A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 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 $(\cot + \cot a)\sin a$ 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, a1)|, |V_f(-45, a1)|)$, with:
 total thickness per orientation, $tf1 = NL*t/NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 267132.42$
 $bw*d = \frac{1}{4} * d*d = 80424.772$

 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 $\theta = 0.00036405$
 $y = (M_y * L_s / 3) / E_{eff} = 0.02022461$ ((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: $E_{eff} = \text{factor} * E_c * I_g = 1.0179E+013$
 $\text{factor} = 0.30$
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.292$
 $E_c * I_g = 3.3929E+013$

 Calculation of Yielding Moment M_y

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

 $M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 M_{y_ten} (8c) = 2.0578E+008
 y_{ten} (7c) = 69.48506
 error of function (7c) = 0.00456662
 M_{y_com} (8d) = 5.0781E+008
 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)
 $d1 = 44.00$
 $R = 200.00$
 $v = 0.00103288$
 $N = 4819.292$
 $A_c = 125663.706$
 ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.4369098$

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_{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

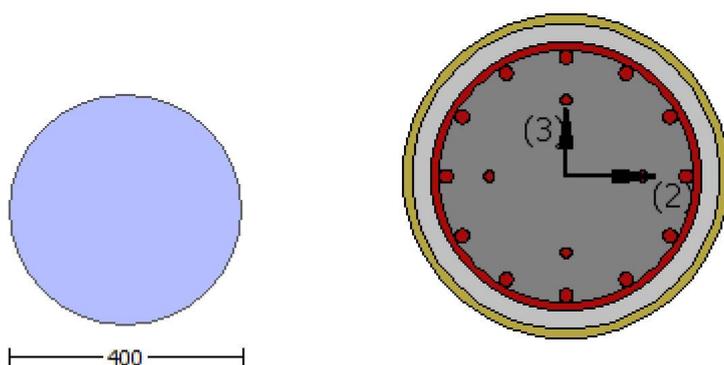
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

New material of 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, $e_{fu} = 0.01$

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

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

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

$M_{u1+} = 2.1596E+008$, 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 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: $f_{cc} = f_c \cdot c = 51.61391$
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/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, $V_{r1} = 451737.695$

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

$V_{CoI0} = 451737.695$

$k_{nl} = 1$ (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).

= 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)
 $M/d = 2.00$
 $\mu_u = 1.1386922E-011$
 $V_u = 8.8188366E-032$

$d = 0.8 \cdot D = 320.00$
 $Nu = 4821.109$
 $Ag = 125663.706$
 From (11.5.4.8), ACI 318-14: $Vs = 219326.297$
 $Av = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $fy = 555.56$
 $s = 100.00$
 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) $\sin \theta + \cos \theta$ 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 $Vf(\theta, \alpha)$, 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: $\theta = b1 + 90^\circ = 90.00$
 $Vf = \text{Min}(|Vf(45, \theta)|, |Vf(-45, \theta)|)$, with:
 total thickness per orientation, $tf1 = NL \cdot t / NoDir = 1.016$
 $dfv = d$ (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: $Vs + Vf \leq 306911.784$
 $bw \cdot d = \sqrt{3} \cdot d^2 / 4 = 80424.772$

 Calculation of Shear Strength at edge 2, $Vr2 = 451737.695$
 $Vr2 = VCol$ ((10.3), ASCE 41-17) = $knl \cdot VCol0$
 $VCol0 = 451737.695$
 $knl = 1$ (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: $Vs = 219326.297$
 $Av = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $fy = 555.56$
 $s = 100.00$
 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) $\sin \theta + \cos \theta$ 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 $Vf(\theta, \alpha)$, 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: $\theta = b1 + 90^\circ = 90.00$
 $Vf = \text{Min}(|Vf(45, \theta)|, |Vf(-45, \theta)|)$, with:
 total thickness per orientation, $tf1 = NL \cdot t / NoDir = 1.016$
 $dfv = d$ (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: $Vs + Vf \leq 306911.784$
 $bw \cdot d = \sqrt{3} \cdot d^2 / 4 = 80424.772$

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, $f_s = 1.25 * f_{sm} = 694.45$

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, $b_i = 0.00^\circ$
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: $As_{l,ten} = 1223.127$
-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

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

$M_{u1+} = 2.1596E+008$, 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 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 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: $f_{cc} = f_c \cdot \lambda = 51.61391$

conf. factor $\lambda = 1.56406$

$f_c = 33.00$

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

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

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: $f_{cc} = f_c \cdot \lambda = 51.61391$

conf. factor $\lambda = 1.56406$

$f_c = 33.00$

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

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$$A_c = 125663.706$$
$$= \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$$

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
 $\mu = 2.1596E+008$

$$= 0.9424778$$

$$\lambda = 0.8362801$$

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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

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
 $\mu = 2.1596E+008$

$$= 0.9424778$$

$$\lambda = 0.8362801$$

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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

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) = $k_{nl} * V_{Col0}$

$V_{Col0} = 451737.695$

$k_{nl} = 1$ (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).

 $k_c = 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$\nu_u = 5.3998017E-048$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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 $\phi_{Col} = 0.00$

$s/d = 0.3125$

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 $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \alpha)|)$, 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: $V_s + V_f \leq 306911.784$

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

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

$V_{r2} = V_{Col}$ ((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).

 $k_c = 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$\nu_u = 5.3998017E-048$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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 $\phi_{Col} = 0.00$

$s/d = 0.3125$

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

This later relation, considered as a function Vf(θ), 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: $\theta = b1 + 90^\circ = 90.00$

Vf = Min(|Vf(45, 1)|, |Vf(-45, a1)|), with:

total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$

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: $V_s + V_f \leq 306911.784$

$bw * d = \rho * d * d / 4 = 80424.772$

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

At local axis: 2

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

At local axis: 2

Integration Section: (a)

Section Type: rccs

Constant Properties

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, $ff_u = 1055.00$

Tensile Modulus, $E_f = 64828.00$

Elongation, $ef_u = 0.01$

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

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

$My = \text{Min}(My_{ten}, My_{com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 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) $e_y = \text{Min}(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $apl = 0.45$ ((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) = $\text{Min}(, 1.25 * * (I_b / I_d)^{2/3}) = 0.4369098$
with f_c^* ((12.3), ACI 440) = 37.12975
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = NL * t * \text{Cos}(b_1) = 1.016$
 e_{fe} ((12.5) and (12.7)) = 0.004
 $f_u = 0.01$
 $E_f = 64828.00$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- Calculation of ρ -

From table 10-9: $\rho = 0.00$

with:

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

$d = 0.00$

$s = 0.00$

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

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

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

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.

$NUD = 4819.292$

$Ag = 125663.706$

$f_{cE} = 33.00$

$f_{yE} = f_{yI} = 555.56$

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

$f_{cE} = 33.00$

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

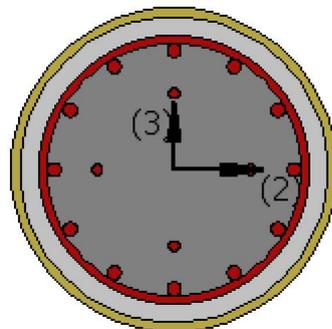
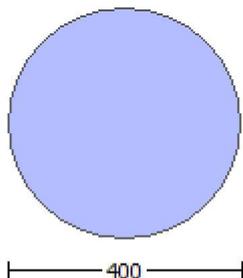
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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, $NoDir = 1$
Fiber orientations, $bi: 0.00^\circ$
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = 9.0989575E-010$
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: $As_{c,com} = 1223.127$
-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 $V_R = 1.0 * V_n = 393310.919$
 $V_n ((10.3), ASCE 41-17) = knl * V_{CoIo} = 393310.919$

VCol = 393310.919
knl = 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)
 $M/Vd = 2.00$
 $\mu_u = 9.0989575E-010$
 $V_u = 3.1724095E-013$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4819.292$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 0.3125$
 V_f ((11-3)-(11.4), 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: $\theta = 45^\circ + 90^\circ = 135^\circ$
 $V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, 1)|)$, 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: $V_s + V_f \leq 267132.42$
 $b_w \cdot d = \sqrt{N_u} \cdot d / 4 = 80424.772$

displacement_ductility_demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 2.6026501E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.01010841$ ((4.29), Biskinis Phd))
 $M_y = 2.0578E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ 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
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.292$
 $E_c \cdot I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 M_{y_ten} (8c) = 2.0578E+008
 M_{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) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b/l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $a_{pl} = 0.45$ ((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), ACI 440) = 37.12975
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
 Effective FRP thickness, $t_f = NL * t * \text{Cos}(b_1) = 1.016$
 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. 4

column C1, Floor 1

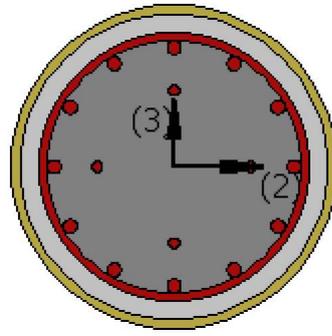
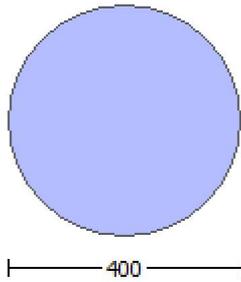
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (3)



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

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

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of 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, $e_{fu} = 0.01$
 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

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 , $V_e/V_r = 0.31871182$

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: $f_{cc} = f_c^* c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

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

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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: $f_{cc} = f_c^* c = 51.61391$

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

$\mu = 2.1596E+008$

$\phi = 0.9424778$

$\phi' = 0.8362801$

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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

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

$\mu = 2.1596E+008$

$\phi = 0.9424778$

$\phi' = 0.8362801$

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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

Calculation of ratio l_b/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) = $k_n l V_{Col0}$

$V_{Col0} = 451737.695$

$k_n l = 1$ (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).

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

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

$M/Vd = 2.00$

$\mu_u = 1.1386922E-011$

$\nu_u = 8.8188366E-032$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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

$A_v = \lambda^2 A_{stirrup} = 123370.055$

$f_y = 555.56$

$s = 100.00$

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 $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ + 90^\circ = 135^\circ$

$V_f = \text{Min}(|V_f(45^\circ, \alpha_1)|, |V_f(-45^\circ, \alpha_1)|)$, with:

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

$d_{fv} = d$ (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: $V_s + V_f \leq 306911.784$

$b_w \cdot d = \lambda^2 \cdot d^2 / 4 = 80424.772$

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

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

$V_{Col0} = 451737.695$

$k_n l = 1$ (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).

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

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

$M/Vd = 2.00$

$\mu_u = 1.1386922E-011$

$\nu_u = 8.8188366E-032$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \sqrt{2} * A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 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
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin^2 + \cos^2$ is replaced with $(\cot^2 + \cot^2)\sin^2\alpha$ which is more a generalised expression,
 where α is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\alpha)$, is implemented for every different fiber orientation α_i ,
 as well as for 2 crack directions, $\alpha = 45^\circ$ and $\alpha = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, 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), 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: $V_s + V_f \leq 306911.784$
 $b_w * d = A_v * d / 4 = 80424.772$

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

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

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of 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, $b_i = 0.00^\circ$
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: $A_{sl,t} = 0.00$
-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
 $\mu_u = 2.1596E+008$

 $\phi = 0.9424778$
 $\lambda = 0.8362801$
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 $l_b/l_d = 0.30$

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: $f_{cc} = f_c \cdot c = 51.61391$

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

$$f_c = 33.00$$

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

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

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: $f_{cc} = f_c \cdot c = 51.61391$

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

$$f_c = 33.00$$

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

$$l_b/l_d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

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), Mu

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

$$= 0.9424778$$

$$' = 0.8362801$$

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, $V_{r1} = 451737.695$

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

$$V_{Col0} = 451737.695$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

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

$$V_u = 5.3998017 \times 10^4$$

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

$$N_u = 4821.109$$

$$A_g = 125663.706$$

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

$$f = 0.95, \text{ for fully-wrapped sections}$$

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

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ + 90^\circ = 135^\circ$

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

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

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

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

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_u = 0.01$$

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

$$b_w \cdot d = \mu \cdot d^2 / 4 = 80424.772$$

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

$V_{r2} = V_{Col}$ ((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 $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$M_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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 $\lambda_{col} = 0.00$

$s/d = 0.3125$

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) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ$ and $\alpha = 90^\circ$

$V_f = \text{Min}(|V_f(45, 90)|, |V_f(-45, 90)|)$, 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: $V_s + V_f \leq 306911.784$

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

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

At local axis: 2

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

At local axis: 3

Integration Section: (a)

Section Type: rccs

Constant Properties

Knowledge Factor, $\lambda = 1.00$

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, $NoDir = 1$
Fiber orientations, $bi = 0.00^\circ$
Number of layers, $NL = 1$
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: $As_t = 1426.283$
-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 $u_{,R} = 1.0^*$ $u = 0.02022461$
 $u = y + p = 0.02022461$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.02022461$ ((4.29), Biskinis Phd))
 $My = 2.0578E+008$
 $L_s = M/V$ (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
 $Ag = 125663.706$
 $fc' = 33.00$
 $N = 4819.292$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment My

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

$My = \text{Min}(My_{ten}, My_{com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 $My_{ten} (8c) = 2.0578E+008$
 $_{ten} (7c) = 69.48506$
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) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.0027778$

$e_{co} = 0.002$

$a_{pl} = 0.45$ ((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), 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 $l_b / l_d = 0.30$

- 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 $V_y E / V_{Co} I_{OE} = 0.31871182$

$d = 0.00$

$s = 0.00$

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

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

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

$N_{UD} = 4819.292$

$A_g = 125663.706$

$f_{cE} = 33.00$

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

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

$f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

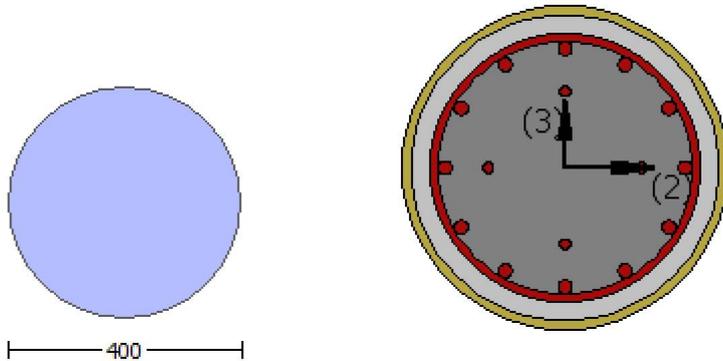
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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, $e_{fu} = 0.01$

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 = -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) = $k_n \cdot V_{CoI} = 393310.919$
 $V_{CoI} = 393310.919$
 $k_n = 1.00$
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 $\phi_{CoI} = 0.00$
 $s/d = 0.3125$
 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 $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta_1 = \theta + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
total thickness per orientation, $t_{f1} = NL \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (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: $V_s + V_f \leq 267132.42$
 $b_w \cdot d = \phi \cdot d^2 / 4 = 80424.772$

displacement_ductility_demand is calculated as δ / y

- Calculation of δ / 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
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.292$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

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

$M_y = \text{Min}(M_{y_ten}, M_{y_com}) = 2.0578E+008$
 $y = 9.1038064E-006$
 M_{y_ten} (8c) = $2.0578E+008$
 δ_{ten} (7c) = 69.48506
error of function (7c) = 0.00456662
 M_{y_com} (8d) = $5.0781E+008$
 δ_{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) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.4369098$
with f_c^* ((12.3), ACI 440) = 37.12975
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = N * L * \text{Cos}(b_1) = 1.016$
 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: 2

Integration Section: (b)

Calculation No. 6

column C1, Floor 1

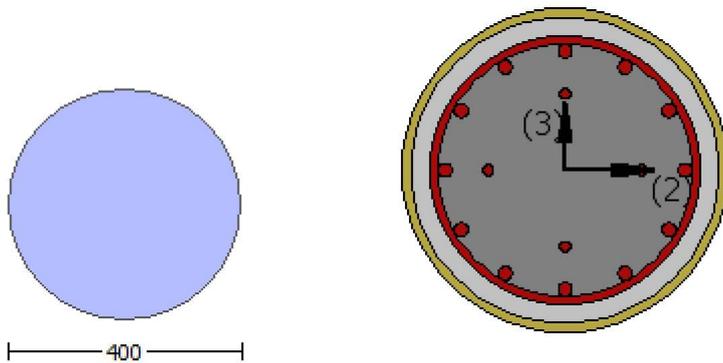
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

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

$\beta_1 = 0.9424778$
 $\beta_2 = 0.8362801$
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: $f_{cc} = f_c^* \quad c = 51.61391$
conf. factor $\gamma_c = 1.56406$
 $f_c = 33.00$
From 10.3.5, ASCE41-17, Final value of f_y : $f_y * \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
 $\beta_1 = \text{Min}(1, 1.25 * (l_b/d)^{2/3}) = 0.30415227$

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: $f_{cc} = f_c' \cdot c = 51.61391$

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

$$f_c = 33.00$$

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, $V_{r1} = 451737.695$

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

$$V_{Col0} = 451737.695$$

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

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

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

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

$$M/d = 2.00$$

$$Mu = 1.1386922E-011$$

$$Vu = 8.8188366E-032$$

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

$$Nu = 4821.109$$

$$A_g = 125663.706$$

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 $\phi_{Col} = 0.00$

$$s/d = 0.3125$$

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

$$f = 0.95, \text{ for fully-wrapped sections}$$

$w_f/s_f = 1$ (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: $\theta = b_1 + 90^\circ = 90.00$

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

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

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

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

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

with $f_u = 0.01$

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

$b_w \cdot d = \frac{1}{4} \cdot d^2 = 80424.772$

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

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

$V_{Col0} = 451737.695$

$k_{nl} = 1$ (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 $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 1.1386922E-011$

$V_u = 8.8188366E-032$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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

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

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$f = 0.95$, for fully-wrapped sections

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

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = \theta_1 = 90^\circ = 90.00$

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

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

$E_f = 64828.00$

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

with $f_u = 0.01$

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

$b_w \cdot d = \frac{1}{4} \cdot d^2 = 80424.772$

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, $\phi = 1.00$

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, $b_i = 0.00^\circ$

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: $As_{,ten} = 1223.127$

-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

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 2.1596E+008$

$\mu_{1+} = 2.1596E+008$, 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 μ_{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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

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, $V_{r1} = 451737.695$

$$V_{r1} = V_{Co1} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Co10}$$

$$V_{Co10} = 451737.695$$

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

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

= 1 (normal-weight concrete)

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

$$M/d = 2.00$$

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

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

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

$$N_u = 4821.109$$

$$A_g = 125663.706$$

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 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d * d / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $kn1 * V_{Col0}$
 $V_{Col0} = 451737.695$
 $kn1 = 1$ (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 $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 4.3208129E-012$
 $V_u = 5.3998017E-048$
 $d = 0.8 * D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \rho / 2 * A_{stirup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 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 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d * d / 4 = 80424.772$

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

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

At local axis: 2

Integration Section: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

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

Consequently:

New material of 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, $N_{oDir} = 1$

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: $A_{st} = 0.00$

-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, $DbL = 17.20$

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 -

$y = (M_y * L_s / 3) / E_{eff} = 0.01010841$ ((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
Ag = 125663.706
fc' = 33.00
N = 4819.292
Ec*Ig = 3.3929E+013

Calculation of Yielding Moment My

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

My = Min(My_ten, My_com) = 2.0578E+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) $\rho_y = \text{Min}(\rho_y, 1.25 * \rho_y * (l_b/l_d)^{2/3}) = 0.0027778$
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) $\rho_y = \text{Min}(\rho_y, 1.25 * \rho_y * (l_b/l_d)^{2/3}) = 0.4369098$
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 lb/l_d

Inadequate Lap Length with lb/l_d = 0.30

- Calculation of ρ_p -

From table 10-9: $\rho_p = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/l_d >= 1

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

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

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

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

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

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

NUD = 4819.292

Ag = 125663.706

f_{cE} = 33.00

f_{yE} = f_{yE} = 555.56

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

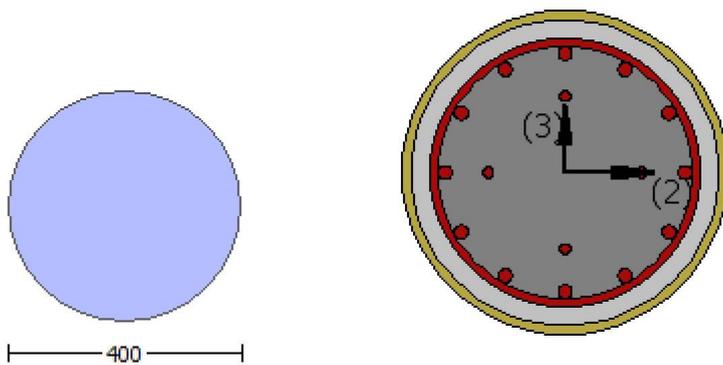
f_{cE} = 33.00

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 VRd
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, $e_{fu} = 0.01$
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: $A_{sl,t} = 0.00$
-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, $D_{bL,ten} = 17.20$

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) = $k_n \cdot V_{CoI0} = 393310.919$
 $V_{CoI} = 393310.919$
 $k_n = 1.00$
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: $V_s = 197392.088$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 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

$wf/sf = 1$ (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, $tf1 = NL*t/NoDir = 1.016$

$dfv = d$ (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: $Vs + Vf \leq 267132.42$

$bw*d = \rho*d*d/4 = 80424.772$

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 $\theta = 1.1801063E-020$

$y = (My*Ls/3)/Eleff = 0.01010841$ ((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

$Ag = 125663.706$

$fc' = 33.00$

$N = 4819.292$

$Ec*Ig = 3.3929E+013$

Calculation of Yielding Moment My

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

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

$y = 9.1038064E-006$

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

My_{ten} (7c) = 69.48506

error of function (7c) = 0.00456662

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

My_{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) $\rho = \text{Min}(\rho, 1.25*\rho*(lb/l_d)^{2/3}) = 0.4369098$

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

$fc = 33.00$

$fl = 1.3173$

$k = 1$

Effective FRP thickness, $tf = NL*t*\text{Cos}(b1) = 1.016$

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

$fu = 0.01$

$Ef = 64828.00$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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

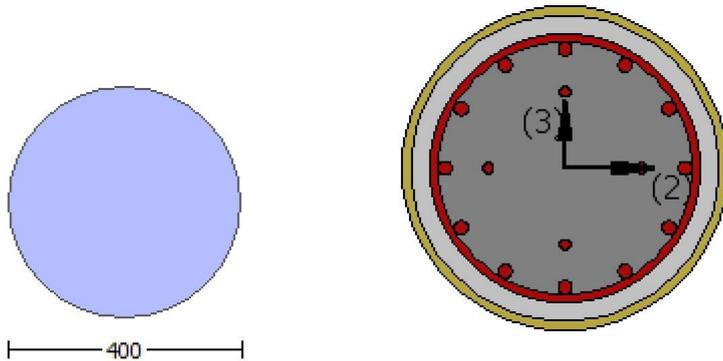
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

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, $e_{fu} = 0.01$
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: $As_{c,com} = 1223.127$
-Middle: $As_{c,mid} = 1223.127$

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: $f_{cc} = f_c \cdot c = 51.61391$
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_{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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

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

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: $f_{cc} = f_c * c = 51.61391$

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) = $k_{nl} * V_{Col0}$

$V_{Col0} = 451737.695$

$k_{nl} = 1$ (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)

$M / Vd = 2.00$

$M_u = 1.1386922E-011$

$V_u = 8.8188366E-032$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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

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

$f_y = 555.56$

$s = 100.00$

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) $\sin \theta + \cos \theta$ 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d * d / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $knl * V_{Col0}$
 $V_{Col0} = 451737.695$
 $knl = 1$ (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 $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.1386922E-011$
 $\nu_u = 8.8188366E-032$
 $d = 0.8 * D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
 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 $Col = 0.00$
 $s/d = 0.3125$
 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) $\sin \theta + \cos \theta$ 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d * d / 4 = 80424.772$

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

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

(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
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, $N_{oDir} = 1$
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: $A_{sl, \text{ten}} = 1223.127$
-Compression: $A_{sl, \text{com}} = 1223.127$
-Middle: $A_{sl, \text{mid}} = 1223.127$

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

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*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 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)

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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

$A_v = \rho_s \cdot A_{stirrup} = 123370.055$

$f_y = 555.56$

$s = 100.00$

V_s is multiplied by $\phi = 0.00$

$s/d = 0.3125$

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) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ$ and $\alpha = 90^\circ$

$V_f = \text{Min}(|V_f(45^\circ, 90^\circ)|, |V_f(-45^\circ, 90^\circ)|)$, with:

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

$d_{fv} = d$ (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: $V_s + V_f \leq 306911.784$

$b_w \cdot d = \rho_s \cdot d^2 / 4 = 80424.772$

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

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

$V_{Col0} = 451737.695$

$\phi = 1$ (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).

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

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

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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

$A_v = \rho_s \cdot A_{stirrup} = 123370.055$

$f_y = 555.56$

$s = 100.00$

V_s is multiplied by $\phi = 0.00$

$s/d = 0.3125$

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) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ$ and $\alpha = 90^\circ$

$V_f = \text{Min}(|V_f(45^\circ, 90^\circ)|, |V_f(-45^\circ, 90^\circ)|)$, with:

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

$dfv = d$ (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: $Vs + Vf \leq 306911.784$
 $bw*d = *d*d/4 = 80424.772$

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

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, $= 1.00$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Secondary Member: Concrete Strength, $fc = fcm = 33.00$
New material of Secondary Member: Steel Strength, $fs = fsm = 555.56$
Concrete Elasticity, $Ec = 26999.444$
Steel Elasticity, $Es = 200000.00$
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 $lb/ld = 0.30$
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, $t = 1.016$
Tensile Strength, $ffu = 1055.00$
Tensile Modulus, $Ef = 64828.00$
Elongation, $efu = 0.01$
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

Bending Moment, $M = 0.03889518$
Shear Force, $V2 = 4539.895$
Shear Force, $V3 = 3.1724095E-013$
Axial Force, $F = -4819.292$
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: $Asl,mid = 1223.127$
Mean Diameter of Tension Reinforcement, $DbL = 17.20$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u, R = 1.0^* u = 0.00202168$
 $u = y + p = 0.00202168$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00202168$ ((4.29), Biskinis Phd))
 $My = 2.0578E+008$
 $Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 300.00
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 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) $ey = \text{Min}(ey, 1.25 * ey * (lb/ld)^{2/3}) = 0.0027778$
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00103288
N = 4819.292
Ac = 125663.706
((10.1), ASCE 41-17) = $\text{Min}(, 1.25 * * (lb/ld)^{2/3}) = 0.4369098$
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 lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

- Calculation of p -

From table 10-9: $p = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $lb/ld \geq 1$
shear control ratio $VyE/ColOE = 0.31871182$
d = 0.00
s = 0.00
 $t = 2 * Av / (dc * s) + 4 * tf / D * (ffe / fs) = 0.00$

$A_v = 78.53982$, 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.

$NUD = 4819.292$

$A_g = 125663.706$

$f_{cE} = 33.00$

$f_{yE} = f_{yI} = 555.56$

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

$f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

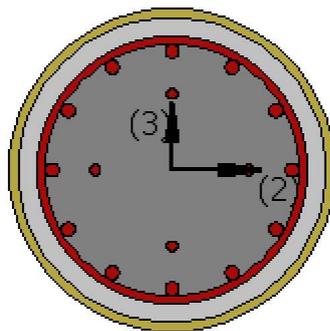
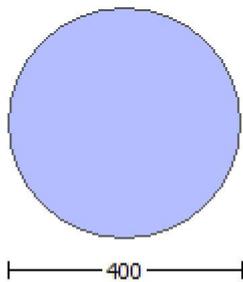
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

New material of 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, $M_a = -8.6091E+006$
 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: $A_{sl,t} = 1426.283$
 -Compression: $A_{sl,c} = 2243.097$
 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, $D_{bL,ten} = 17.20$

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), 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: $\theta = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, a_1)|)$, with:
 total thickness per orientation, $t_{f1} = N_L \cdot t / \text{NoDir} = 1.016$
 $d_{fv} = d$ (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: $V_s + V_f \leq 267132.42$
 $b_w \cdot d = \frac{1}{4} \cdot d \cdot d = 80424.772$

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 $\theta = 0.00023003$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.02022462$ ((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 / y 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
 δ_{ten} (7c) = 69.48507
 error of function (7c) = 0.00456648
 M_{y_com} (8d) = 5.0781E+008
 δ_{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)
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00103303$

$N = 4819.961$
 $A_c = 125663.706$
 $\left(\frac{10.1}{ASCE\ 41-17}\right) = \text{Min}\left(\quad, 1.25 \cdot \left(\frac{l_b}{l_d}\right)^{2/3}\right) = 0.4369098$
 with $f_c^* \left(\frac{12.3}{ACI\ 440}\right) = 37.12975$
 $f_c = 33.00$
 $f_l = 1.3173$
 $k = 1$
 Effective FRP thickness, $t_f = NL \cdot t \cdot \cos(b_1) = 1.016$
 $e_{fe} \left(\frac{12.5}{\text{and } (12.7)}\right) = 0.004$
 $f_u = 0.01$
 $E_f = 64828.00$

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: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

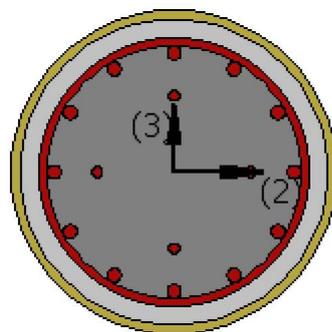
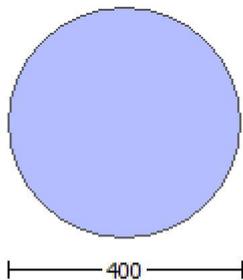
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_r)

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, $e_{fu} = 0.01$
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

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
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.1596E+008$
 $M_{u1+} = 2.1596E+008$, 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 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 μ_{1+}

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

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

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
 $\mu = 2.1596E+008$

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

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), 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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of 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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

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, $V_{r1} = 451737.695$

$V_{r1} = V_{Co1}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{Co10}$

$V_{Co10} = 451737.695$

$k_{nl} = 1$ (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)

$$M/Vd = 2.00$$

$$\mu_u = 1.1386922E-011$$

$$\mu_v = 8.8188366E-032$$

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

$$N_u = 4821.109$$

$$A_g = 125663.706$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 219326.297$$

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

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$f = 0.95, \text{ for fully-wrapped sections}$$

$$w_f/s_f = 1 \text{ (FRP strips adjacent to one another).}$$

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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.

$$\text{orientation 1: } \theta = 45^\circ + 90^\circ = 135^\circ$$

$$V_f = \text{Min}(|V_f(45^\circ, \alpha_1)|, |V_f(-45^\circ, \alpha_1)|), \text{ with:}$$

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

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

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

$$E_f = 64828.00$$

$$f_{e1} = 0.004, \text{ from (11.6a), ACI 440}$$

$$\text{with } f_{u1} = 0.01$$

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

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

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

$$V_{r2} = \phi_{\text{col}} \cdot V_{\text{col0}} \text{ ((10.3), ASCE 41-17) } = \phi_{\text{col}} \cdot V_{\text{col0}}$$

$$V_{\text{col0}} = 451737.695$$

$$\phi_{\text{col}} = 1 \text{ (zero step-static loading)}$$

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

$$f_c' = 33.00 \text{ (normal-weight concrete)}$$

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

$$M/Vd = 2.00$$

$$\mu_u = 1.1386922E-011$$

$$\mu_v = 8.8188366E-032$$

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

$$N_u = 4821.109$$

$$A_g = 125663.706$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 219326.297$$

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

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$f = 0.95, \text{ for fully-wrapped sections}$$

$$w_f/s_f = 1 \text{ (FRP strips adjacent to one another).}$$

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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.

$$\text{orientation 1: } \theta = 45^\circ + 90^\circ = 135^\circ$$

$$V_f = \text{Min}(|V_f(45^\circ, \alpha_1)|, |V_f(-45^\circ, \alpha_1)|), \text{ with:}$$

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

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

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

$$E_f = 64828.00$$

$$f_{e1} = 0.004, \text{ from (11.6a), ACI 440}$$

with $f_u = 0.01$

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

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

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

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

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

New material of 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, $e_{fu} = 0.01$

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

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: $A_{sl,ten} = 1223.127$

-Compression: $Asl,com = 1223.127$
-Middle: $Asl,mid = 1223.127$

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

$Mu = 2.1596E+008$

$\phi = 0.9424778$

$\lambda = 0.8362801$

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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$

$l_b/l_d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_{1-}

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

$Mu = 2.1596E+008$

$\phi = 0.9424778$

$\lambda = 0.8362801$

error of function (3.68), Biskinis Phd = 53851.649

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

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, $V_{r1} = 451737.695$

$V_{r1} = V_{Col}$ ((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).

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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 $\text{Col} = 0.00$

$s/d = 0.3125$

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 $V_f(\theta, a)$, 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: $\theta = b_1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a)|)$, 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: $V_s + V_f \leq 306911.784$

$b_w d = \frac{1}{4} d^2 = 80424.772$

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

$V_{r2} = V_{Col}$ ((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).

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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

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) $\sin \theta + \cos \theta$ 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 Vf(θ , α), is implemented for every different fiber orientation ai, 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 = Min(|Vf(45, θ)|, |Vf(-45, θ)|), with:

total thickness per orientation, tf1 = NL*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 <= 306911.784

bw*d = $\frac{V_s + V_f}{f_e} \leq \frac{d}{4} = 80424.772$

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, $\gamma = 1.00$

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, $e_{fu} = 0.01$

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

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: $As_{,ten} = 1223.127$
 -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 $u_{,R} = 1.0^*$ $u = 0.04010842$
 $u = y + p = 0.04010842$

- Calculation of y -

$y = (My * Ls / 3) / E_{eff} = 0.01010842$ ((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: $E_{eff} = factor * E_c * I_g = 1.0179E+013$
 $factor = 0.30$
 $Ag = 125663.706$
 $fc' = 33.00$
 $N = 4819.961$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment My

Calculation of 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) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.0027778$
 $e_{co} = 0.002$
 $apl = 0.45$ ((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) = $\text{Min}(, 1.25 * * (l_b / l_d)^{2/3}) = 0.4369098$
 with fc^* ((12.3), ACI 440) = 37.12975
 $fc = 33.00$
 $fl = 1.3173$
 $k = 1$
 Effective FRP thickness, $t_f = NL * t * \text{Cos}(b1) = 1.016$
 e_{fe} ((12.5) and (12.7)) = 0.004
 $fu = 0.01$
 $E_f = 64828.00$

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 $V_y E / V_{CoI} E = 0.31871182$

$$d = 0.00$$

$$s = 0.00$$

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

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

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

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

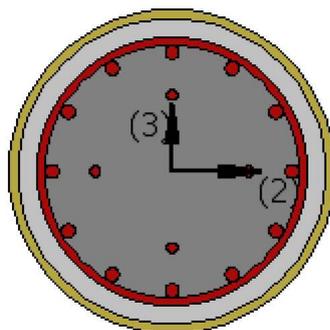
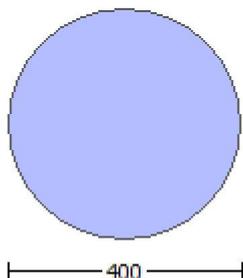
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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 $l_o/l_{o,min} = l_b/l_d = 0.30$

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, $NoDir = 1$

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: $As_t = 1426.283$

-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) = $k_n \cdot V_{CoIO} = 393311.051$
 $V_{CoI} = 393311.051$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00$

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).

$\lambda = 1$ (normal-weight concrete)
 $f_c' = 25.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 5.7912052E-010$
 $V_u = 2.0045250E-013$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4819.961$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$

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 $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ + 90^\circ = 135^\circ$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \alpha)|)$, 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: $V_s + V_f \leq 267132.42$
 $b_w \cdot d = \sqrt{2} \cdot d^2 / 4 = 80424.772$

$displacement_ductility_demand$ is calculated as ϕ / γ

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

From analysis, chord rotation $\theta = 1.6445157E-020$
 $\gamma = (M_y \cdot L_s / 3) / E_{eff} = 0.01010842$ ((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: $E_{eff} = factor \cdot E_c \cdot I_g = 1.0179E+013$
 $factor = 0.30$
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.961$
 $E_c \cdot I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ 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

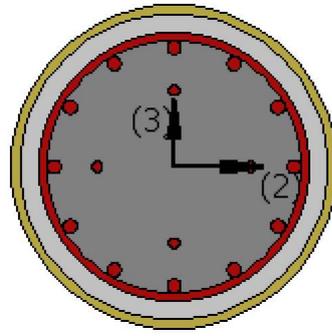
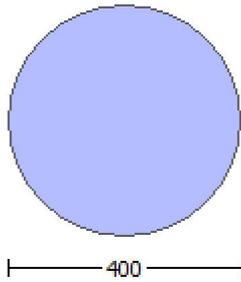
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (3)



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

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

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of 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, $e_{fu} = 0.01$
 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: 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 , $V_e/V_r = 0.31871182$

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 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 the static loading combination

Calculation of M_{u1+}

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: $f_{cc} = f_c^* c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

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

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_{u1-}

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: $f_{cc} = f_c^* c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

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

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$Ac = 125663.706$

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

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, 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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$Ac = 125663.706$

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

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, 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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$Ac = 125663.706$

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

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, $V_{r1} = 451737.695$

$V_{r1} = V_{Col}$ ((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).

$\lambda = 1$ (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: $V_s = 219326.297$

$A_v = \lambda^2 A_{stirrup} = 123370.055$

$f_y = 555.56$

$s = 100.00$

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) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ + 90^\circ = 135^\circ$

$V_f = \text{Min}(|V_f(45^\circ, \alpha_1)|, |V_f(-45^\circ, \alpha_1)|)$, 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: $V_s + V_f \leq 306911.784$

$b_w d = \lambda^2 d^2 / 4 = 80424.772$

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

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

$V_{Col0} = 451737.695$

$k_n l = 1$ (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).

$\lambda = 1$ (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: $V_s = 219326.297$
 $A_v = \sqrt{2} * A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 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
 $w_f/s_f = 1$ (FRP strips adjacent to one another).
 In (11.3) $\sin^2 + \cos^2$ is replaced with $(\cot^2 + \cot^2)\sin^2\alpha$ which is more a generalised expression,
 where α is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function $V_f(\alpha)$, is implemented for every different fiber orientation α_i ,
 as well as for 2 crack directions, $\alpha = 45^\circ$ and $\alpha = -45^\circ$ to take into consideration the cyclic seismic loading.
 orientation 1: $\alpha_1 = b_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \alpha_1)|, |V_f(-45, \alpha_1)|)$, with:
 total thickness per orientation, $t_{f1} = NL * t / NoDir = 1.016$
 $d_{fv} = d$ (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: $V_s + V_f \leq 306911.784$
 $b_w * d = A_v * d / 4 = 80424.772$

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

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

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of 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, $b_i = 0.00^\circ$
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: $A_{sl,t} = 0.00$
-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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$
 $l_b/d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$
 $v = 0.00102726$
 $N = 4821.109$
 $A_c = 125663.706$
= $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 0.30415227$

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: $f_{cc} = f_c \cdot c = 51.61391$

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

$$f_c = 33.00$$

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 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: $f_{cc} = f_c \cdot c = 51.61391$

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

$$f_c = 33.00$$

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 μ_{2-}

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

$$\text{Mu} = 2.1596\text{E}+008$$

$$= 0.9424778$$

$$\rho = 0.8362801$$

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 fy: $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d_1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

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, $V_{r1} = 451737.695$

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

$$V_{CoI0} = 451737.695$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

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

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

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

$$N_u = 4821.109$$

$$A_g = 125663.706$$

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

$$A_v = \rho_s \cdot A_{\text{stirrup}} = 123370.055$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$f = 0.95, \text{ for fully-wrapped sections}$$

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

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = b_1 + 90^\circ = 90.00$

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

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

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI } 440$$

$$\text{with } f_u = 0.01$$

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

$$b_w \cdot d = \rho_s \cdot d^2 / 4 = 80424.772$$

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

$V_{r2} = V_{Col}$ ((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 $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / V d = 2.00$

$\mu_u = 4.3208129E-012$

$\nu_u = 5.3998017E-048$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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

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

$f_y = 555.56$

$s = 100.00$

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) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ$ and $\alpha = 90^\circ$

$V_f = \text{Min}(|V_f(45, 90)|, |V_f(-45, 90)|)$, 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: $V_s + V_f \leq 306911.784$

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

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

At local axis: 2

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

At local axis: 3

Integration Section: (a)

Section Type: rccs

Constant Properties

Knowledge Factor, $\lambda = 1.00$

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, $NoDir = 1$
Fiber orientations, $bi = 0.00^\circ$
Number of layers, $NL = 1$
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: $As_t = 1426.283$
-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 $u_{,R} = 1.0^*$ $u = 0.05022462$
 $u = y + p = 0.05022462$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.02022462$ ((4.29), Biskinis Phd))
 $My = 2.0578E+008$
 $L_s = M/V$ (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
 $A_g = 125663.706$
 $fc' = 33.00$
 $N = 4819.961$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment My

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

$My = \text{Min}(My_{,ten}, My_{,com}) = 2.0578E+008$
 $y = 9.1038084E-006$
 $My_{,ten} (8c) = 2.0578E+008$
 $_{,ten} (7c) = 69.48507$
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) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.0027778$

$e_{co} = 0.002$

$a_{pl} = 0.45$ ((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 $l_b / l_d = 0.30$

- 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 $V_y E / V_{Co} I_{OE} = 0.31871182$

$d = 0.00$

$s = 0.00$

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

$A_v = 78.53982$, 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.

$N_{UD} = 4819.961$

$A_g = 125663.706$

$f_{cE} = 33.00$

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

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

$f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

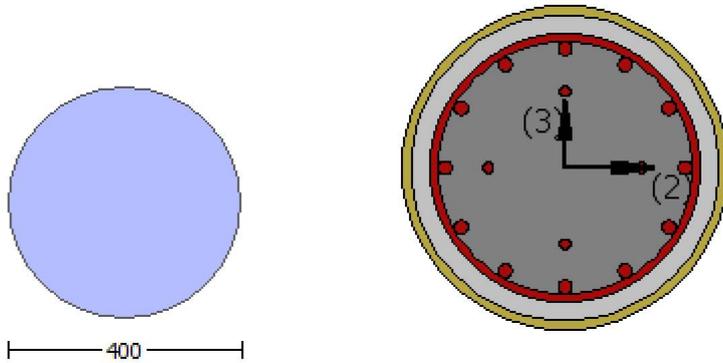
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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, $e_{fu} = 0.01$

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) = $k_n \cdot V_{CoI} = 393311.051$
 $V_{CoI} = 393311.051$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.06274869$

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: $V_s = 197392.088$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 V_s is multiplied by $\phi_{CoI} = 0.00$
 $s/d = 0.3125$
 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 $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = \theta_1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta_1)|, |V_f(-45, \theta_1)|)$, with:
total thickness per orientation, $t_{f1} = NL \cdot t / NoDir = 1.016$
 $d_{fv} = d$ (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: $V_s + V_f \leq 267132.42$
 $b_w \cdot d = \phi \cdot d^2 / 4 = 80424.772$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation = 0.00012686
 $y = (M_y * L_s / 3) / E_{eff} = 0.00202168$ ((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
 $A_g = 125663.706$
 $f_c' = 33.00$
 $N = 4819.961$
 $E_c * I_g = 3.3929E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ 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) = $2.0578E+008$
 ϕ_{ten} (7c) = 69.48507
error of function (7c) = 0.00456648
 M_{y_com} (8d) = $5.0781E+008$
 ϕ_{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) $e_y = \text{Min}(e_y, 1.25 * e_y * (l_b / l_d)^{2/3}) = 0.4369098$
with f_c^* ((12.3), ACI 440) = 37.12975
 $f_l = 33.00$
 $f_l = 1.3173$
 $k = 1$
Effective FRP thickness, $t_f = NL * t * \text{Cos}(b_1) = 1.016$
 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: 2

Integration Section: (b)

Calculation No. 14

column C1, Floor 1

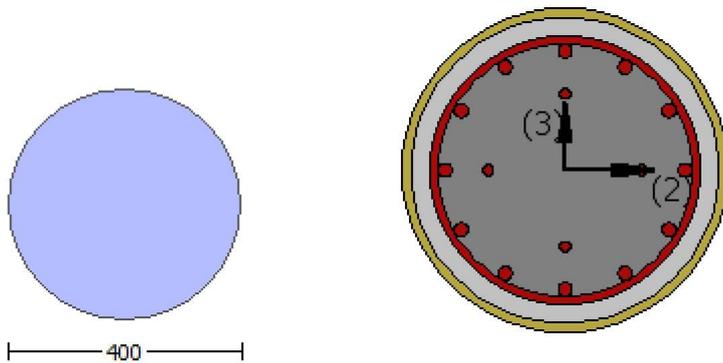
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

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

$\beta_1 = 0.9424778$
 $\beta_2 = 0.8362801$
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 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: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$f_c = 33.00$

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

$$lb/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

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

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of 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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}) = 389.0139$

$$lb/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

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

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of 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: $f_{cc} = f_c' \cdot c = 51.61391$

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

$$f_c = 33.00$$

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, $V_{r1} = 451737.695$

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

$$V_{Col0} = 451737.695$$

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

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

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

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

$$M/d = 2.00$$

$$Mu = 1.1386922E-011$$

$$Vu = 8.8188366E-032$$

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

$$Nu = 4821.109$$

$$Ag = 125663.706$$

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

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

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

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

$$f = 0.95, \text{ for fully-wrapped sections}$$

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

In (11.3) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ + 90^\circ = 135^\circ$

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

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

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

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

$$E_f = 64828.00$$

$$f_e = 0.004, \text{ from (11.6a), ACI 440}$$

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

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

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

V_s is multiplied by $\lambda = 1.00$
 $s/d = 0.3125$

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 $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ + 90^\circ = 135^\circ$

$V_f = \text{Min}(|V_f(45, 1)|, |V_f(-45, 1)|)$, with:

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

$d_{fv} = d$ (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: $V_s + V_f \leq 306911.784$

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

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

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

Constant Properties

Knowledge Factor, $\lambda = 1.00$

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, $e_{fu} = 0.01$

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: $As_{c,com} = 1223.127$

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

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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$l_b/d = 0.30$

$d_1 = 44.00$

$R = 200.00$

$v = 0.00102726$

$N = 4821.109$

$A_c = 125663.706$

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

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) = $k_{nl} \cdot V_{Co10}$

$V_{Co10} = 451737.695$

$k_{nl} = 1$ (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)

$M/d = 2.00$

$\mu = 4.3208129E-012$

$V_u = 5.3998017E-048$

$d = 0.8 \cdot D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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
 $wf/sf = 1$ (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 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d^2 / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col}$ ((10.3), 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 $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 4.3208129E-012$
 $V_u = 5.3998017E-048$
 $d = 0.8 * D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \rho / 2 * A_{stirup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 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 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, with:
total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d^2 / 4 = 80424.772$

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

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

At local axis: 2

Integration Section: (b)

Section Type: rccs

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

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

Consequently:

New material of 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, $N_{oDir} = 1$

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, $DbL = 17.20$

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 -

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

$M_y = 2.0578E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ 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
Ag = 125663.706
fc' = 33.00
N = 4819.961
Ec*Ig = 3.3929E+013

Calculation of Yielding Moment My

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

My = Min(My_ten, My_com) = 2.0578E+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) $\rho_y = \text{Min}(\rho_y, 1.25 * \rho_y * (l_b/l_d)^{2/3}) = 0.0027778$
eco = 0.002
apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
d1 = 44.00
R = 200.00
v = 0.00103303
N = 4819.961
Ac = 125663.706
((10.1), ASCE 41-17) $\rho_y = \text{Min}(\rho_y, 1.25 * \rho_y * (l_b/l_d)^{2/3}) = 0.4369098$
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 lb/l_d

Inadequate Lap Length with lb/l_d = 0.30

- Calculation of ρ_p -

From table 10-9: $\rho_p = 0.03$

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/l_d >= 1

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

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

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

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

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

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

NUD = 4819.961

Ag = 125663.706

f'cE = 33.00

fytE = fyE = 555.56

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

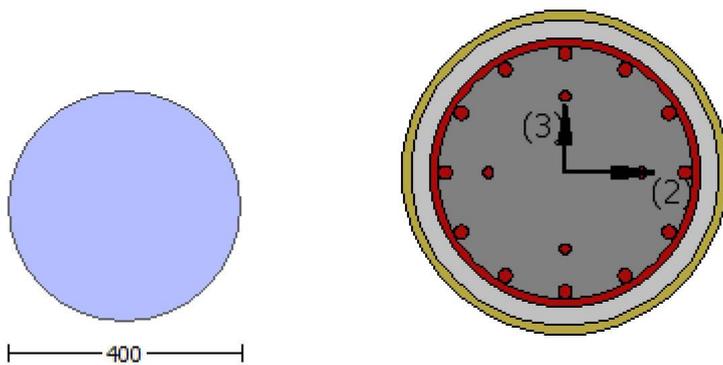
f'cE = 33.00

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 VRd
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 $l_o/l_{o,min} = l_b/l_d = 0.30$
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, 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: $A_{sl,t} = 0.00$
-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, $D_{bL,ten} = 17.20$

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) = $k_n l \cdot V_{CoI0} = 393311.051$
 $V_{CoI} = 393311.051$
 $k_n l = 1.00$
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)
 $M/Vd = 2.00$
 $M_u = 2.2473986E-011$
 $V_u = 2.0045250E-013$
 $d = 0.8 \cdot D = 320.00$
 $N_u = 4819.961$
 $A_g = 125663.706$
From (11.5.4.8), ACI 318-14: $V_s = 197392.088$
 $A_v = \sqrt{2} \cdot A_{stirrup} = 123370.055$
 $f_y = 500.00$
 $s = 100.00$
 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

$wf/sf = 1$ (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: $\theta = b1 + 90^\circ = 90.00$

$V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, a1)|)$, 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), 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: $V_s + V_f \leq 267132.42$

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

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 $\theta = 7.4566431E-021$

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

$M_y = 2.0578E+008$

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

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

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 δ / y 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

δ_{y_ten} (7c) = 69.48507

error of function (7c) = 0.00456648

M_{y_com} (8d) = 5.0781E+008

δ_{y_com} (7d) = 68.37715

error of function (7d) = -0.00101202

with ((10.1), ASCE 41-17) $e_y = \text{Min}(e_y, 1.25 * e_y * (I_b / I_d)^{2/3}) = 0.0027778$

$e_{co} = 0.002$

$a_{pl} = 0.45$ ((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) $e = \text{Min}(e, 1.25 * e * (I_b / I_d)^{2/3}) = 0.4369098$

with f_c^* ((12.3), ACI 440) = 37.12975

$f_c = 33.00$

$f_l = 1.3173$

$k = 1$

Effective FRP thickness, $t_f = NL * t * \text{Cos}(b1) = 1.016$

e_{fe} ((12.5) and (12.7)) = 0.004

$f_u = 0.01$

$E_f = 64828.00$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

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

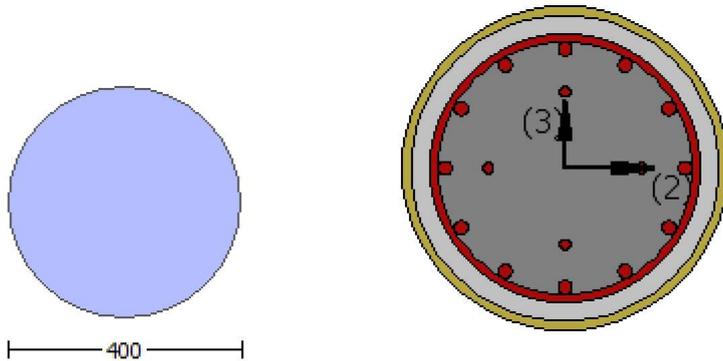
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

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, e_{fu} = 0.01
Number of directions, NoDir = 1
Fiber orientations, b_i : 0.00°
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: 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: $A_{st,mid}$ = 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: $f_{cc} = f_c \cdot c = 51.61391$
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_{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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}) = 389.0139$
 $l_b/l_d = 0.30$
 $d_1 = 44.00$
 $R = 200.00$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

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

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: $f_{cc} = f_c * c = 51.61391$

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) = $k_{nl} * V_{Col0}$

$V_{Col0} = 451737.695$

$k_{nl} = 1$ (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)

$M / Vd = 2.00$

$M_u = 1.1386922E-011$

$V_u = 8.8188366E-032$

$d = 0.8 * D = 320.00$

$N_u = 4821.109$

$A_g = 125663.706$

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

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

$f_y = 555.56$

$s = 100.00$

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) $\sin \theta + \cos \theta$ 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d * d / 4 = 80424.772$

Calculation of Shear Strength at edge 2, $V_{r2} = 451737.695$
 $V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $knl * V_{Col0}$
 $V_{Col0} = 451737.695$
 $knl = 1$ (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 $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M / Vd = 2.00$
 $\mu_u = 1.1386922E-011$
 $\nu_u = 8.8188366E-032$
 $d = 0.8 * D = 320.00$
 $N_u = 4821.109$
 $A_g = 125663.706$
 From (11.5.4.8), ACI 318-14: $V_s = 219326.297$
 $A_v = \rho * A_{stirrup} = 123370.055$
 $f_y = 555.56$
 $s = 100.00$
 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) $\sin \theta + \cos \theta$ 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: $\theta = b1 + 90^\circ = 90.00$
 $V_f = \text{Min}(|V_f(45, \theta)|, |V_f(-45, \theta)|)$, with:
 total thickness per orientation, $tf1 = NL * t / NoDir = 1.016$
 $dfv = d$ (figure 11.2, ACI 440) = 370.00
 ffe ((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: $V_s + V_f \leq 306911.784$
 $bw * d = \rho * d * d / 4 = 80424.772$

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

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

(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
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, $e_{fu} = 0.01$
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

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

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: $f_{cc} = f_c \cdot c = 51.61391$

conf. factor $c = 1.56406$

$$f_c = 33.00$$

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

$$l_b/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of 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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$A_c = 125663.706$$

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

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of 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 : $f_y \cdot \text{Min}(1, 1.25 \cdot (l_b/d)^{2/3}) = 389.0139$

$$l_b/d = 0.30$$

$$d1 = 44.00$$

$$R = 200.00$$

$$v = 0.00102726$$

$$N = 4821.109$$

$$Ac = 125663.706$$

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

Calculation of ratio lb/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

$$= 0.9424778$$

$$' = 0.8362801$$

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 lb/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) = $k_{nl} \cdot V_{Col0}$

$$V_{Col0} = 451737.695$$

$k_{nl} = 1$ (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).

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

$f'_c = 33.00$, but $f'_c \leq 8.3 \text{ MPa}$ (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: $V_s = 219326.297$

$A_v = \rho_s \cdot A_{\text{stirrup}} = 123370.055$

$f_y = 555.56$

$s = 100.00$

V_s is multiplied by $\phi = 0.00$

$s/d = 0.3125$

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) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ$ and $\alpha = 90^\circ$

$V_f = \text{Min}(|V_f(45^\circ, 90^\circ)|, |V_f(-45^\circ, 90^\circ)|)$, 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: $V_s + V_f \leq 306911.784$

$b_w \cdot d = \rho_s \cdot d^2 / 4 = 80424.772$

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

$V_{r2} = \phi V_{c0} = \phi V_{c0}$ ((10.3), ASCE 41-17) = ϕV_{c0}

$V_{c0} = 451737.695$

$\phi = 1$ (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).

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

$f'_c = 33.00$, but $f'_c \leq 8.3 \text{ MPa}$ (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: $V_s = 219326.297$

$A_v = \rho_s \cdot A_{\text{stirrup}} = 123370.055$

$f_y = 555.56$

$s = 100.00$

V_s is multiplied by $\phi = 0.00$

$s/d = 0.3125$

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) $\sin \theta + \cos \theta$ is replaced with $(\cot \theta + \csc \theta) \sin \alpha$ 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: $\theta = 45^\circ$ and $\alpha = 90^\circ$

$V_f = \text{Min}(|V_f(45^\circ, 90^\circ)|, |V_f(-45^\circ, 90^\circ)|)$, with:

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

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 <= 306911.784
bw*d = *d*d/4 = 80424.772

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

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 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 lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 0.02457639
Shear Force, V2 = 2868.587
Shear Force, V3 = 2.0045250E-013
Axial Force, F = -4819.961
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
Mean Diameter of Tension Reinforcement, DbL = 17.20

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u, R = 1.0^* u = 0.03202168$
 $u = y + p = 0.03202168$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00202168$ ((4.29), Biskinis Phd)
 $My = 2.0578E+008$
 $Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 1.0179E+013$
factor = 0.30
Ag = 125663.706
fc' = 33.00
N = 4819.961
 $Ec * Ig = 3.3929E+013$

Calculation of Yielding Moment My

Calculation of 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) = $\text{Min}(, 1.25 * * (lb/ld)^{2/3}) = 0.4369098$
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 lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

- Calculation of p -

From table 10-9: $p = 0.03$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $lb/ld \geq 1$
shear control ratio $VyE/ColOE = 0.31871182$
d = 0.00
s = 0.00
 $t = 2 * Av / (dc * s) + 4 * tf / D * (ffe / fs) = 0.00$

$A_v = 78.53982$, 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.

$N_{UD} = 4819.961$

$A_g = 125663.706$

$f_{cE} = 33.00$

$f_{yE} = f_{yI} = 555.56$

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

$f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (b)
