# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

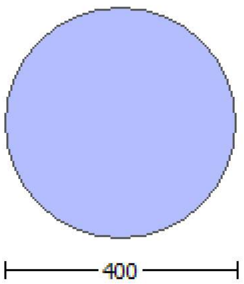
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

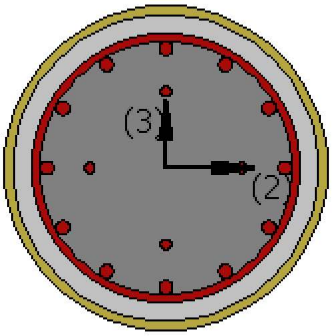
Analysis: Uniform +X

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, κ = 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, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00
#################################################################
Note: Especially for the calculation of θy 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, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 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 lo/lou,min =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
-------------------------------------------------------------------
EDGE -A-
Bending Moment, Ma = -1.3625E+007
Shear Force, Va = -4539.895
EDGE -B-
Bending Moment, Mb = 0.03889518
Shear Force, Vb = 4539.895
BOTH EDGES
Axial Force, F = -4819.292
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1426.283
-Compression: Aslc = 2243.097
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,ten = 17.20
-------------------------------------------------------------------
-------------------------------------------------------------------

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 330221.669
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 330221.669
VCol = 330221.669
knl = 1.00
displacement_ductility_demand = 0.01800015
-------------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.3625E+007
Vu = 4539.895
d = 0.8*D = 320.00

Nu = 4819.292
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 197392.088
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 267132.42
bw*d = π*d*d/4 = 80424.772
-------------------------------------------------------------

-------------------------------------------------------------
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -
for rotation axis 3 and integ. section (a)
-------------------------------------------------------------
From analysis, chord rotation θ = 0.00036405
θy = (My*Ls/3)/Eleff = 0.02022461 ((4.29),Biskinis Phd))
My = 2.0578E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.156
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.0179E+013
factor = 0.30
Ag = 125663.706
fc' = 33.00
N = 4819.292
Ec*Ig = 3.3929E+013
-------------------------------------------------------------
-------------------------------------------------------------

Calculation of Yielding Moment My
-------------------------------------------------------------
Calculation of Φy and My according to (7) - (8) in Biskinis and Fardis
-------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038064E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48506
error of function (7c) = 0.00456662
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098

with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

---

---

Calculation of ratio lb/ld

---

Inadequate Lap Length with lb/ld = 0.30

---

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

---

## Calculation No. 2

column C1, Floor 1

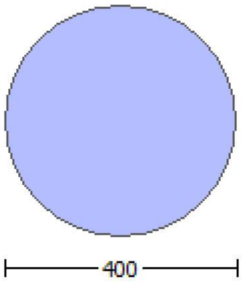
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

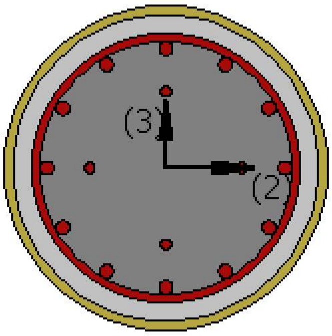
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

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, κ = 1.00
Mean strength values are used for both shear and moment calculations.

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
################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-----------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 8.8188366E-032
EDGE -B-
Shear Force, Vb = -8.8188366E-032
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-----------------------------------------------------------------
-----------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu1-
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------------------

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

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

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032

d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
--------------------------------------------------------------
--------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
--------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
##############################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
---------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -5.3998017E-048
EDGE -B-
Shear Force, Vb = 5.3998017E-048
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
---------------------------------------------------------------

---------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu1-
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109

Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu2+
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
-------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125

Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 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 = 9.0989575E-010
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 = 1426.283
-Compression: Aslc = 2243.097
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 θu,R = 1.0*θu = 0.01010841
θu = θy + θp = 0.01010841

----------------------------------------------------------------
- Calculation of θy -
----------------------------------------------------------------
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
----------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038064E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48506
error of function (7c) = 0.00456662
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
----------------------------------------------------------------
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30

---------------------------------------------------------------
- Calculation of θp -
---------------------------------------------------------------
From table 10-9: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.31871182
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf 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
fytE = fylE = 555.56
pl = 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

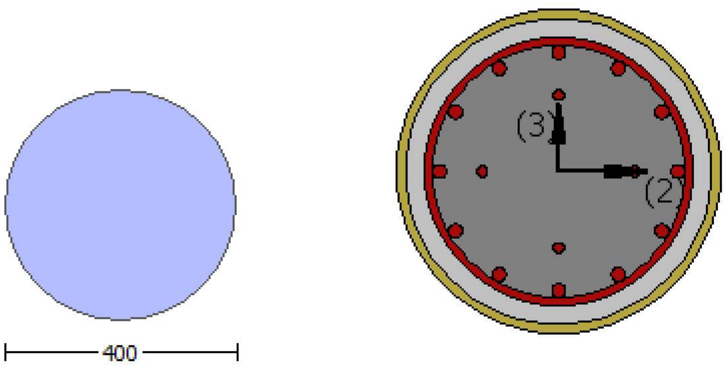
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)




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

At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties
---------------------------------------------------------------
Knowledge Factor, κ = 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, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
################################################################
Note: Especially for the calculation of θy 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, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 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 lo/lou,min =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
---------------------------------------------------------------
EDGE -A-
Bending Moment, Ma = 9.0989575E-010
Shear Force, Va = -3.1724095E-013
EDGE -B-
Bending Moment, Mb = 4.2202164E-011
Shear Force, Vb = 3.1724095E-013
BOTH EDGES
Axial Force, F = -4819.292
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1426.283
-Compression: Aslc = 2243.097
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,ten = 17.20
---------------------------------------------------------------
---------------------------------------------------------------

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 393310.919
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 393310.919

VCol = 393310.919
knl = 1.00
displacement_ductility_demand = 0.00
-----------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.0989575E-010
Vu = 3.1724095E-013
d = 0.8*D = 320.00
Nu = 4819.292
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 197392.088
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 267132.42
bw*d = π*d*d/4 = 80424.772
-----------------------------------------------------------------

-----------------------------------------------------------------
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -
for rotation axis 2 and integ. section (a)
-----------------------------------------------------------------
From analysis, chord rotation θ = 2.6026501E-020
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
-----------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038064E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48506

error of function (7c) = 0.00456662
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
--------------------------------------------------------------
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

--------------------------------------------------------------

## Calculation No. 4

column C1, Floor 1

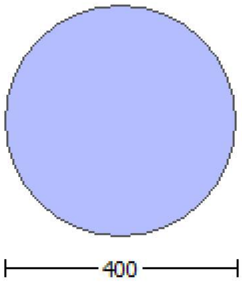
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

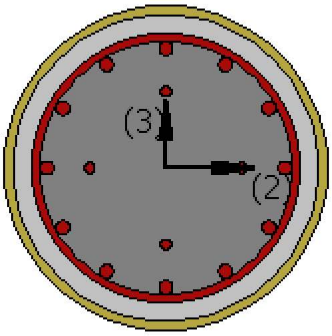
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-----------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 8.8188366E-032
EDGE -B-
Shear Force, Vb = -8.8188366E-032
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
Calculation of Mu1-
----------------------------------------------------------------------------

----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406

fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2-
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227

------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109

Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
---------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -5.3998017E-048
EDGE -B-
Shear Force, Vb = 5.3998017E-048
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr  =  0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 =  Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 =  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
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld

------------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
Calculation of Mu1-
----------------------------------------------------------------------------------

----------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
----------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
Calculation of Mu2+
----------------------------------------------------------------------------------

----------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
----------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
Calculation of Mu2-
----------------------------------------------------------------------------------

----------------------------------------------------------------------------------

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772

---------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
---------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 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 = -1.3625E+007
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 = 1426.283
-Compression: Aslc = 2243.097
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 θu,R = 1.0*θu = 0.02022461
θu = θy + θp = 0.02022461

-------------------------------------------------------------
- Calculation of θy -
-------------------------------------------------------------
θy = (My*Ls/3)/EIeff = 0.02022461 ((4.29),Biskinis Phd))
My = 2.0578E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.156
From table 10.5, ASCE 41_17: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
-------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038064E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48506
error of function (7c) = 0.00456662
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101203

with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00

---

---

Calculation of ratio lb/ld

---

Inadequate Lap Length with lb/ld = 0.30

---

- Calculation of θp -

---

From table 10-9: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.31871182
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf 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
fytE = fylE = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.0292
f'cE = 33.00

---

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

---

## Calculation No. 5

column C1, Floor 1

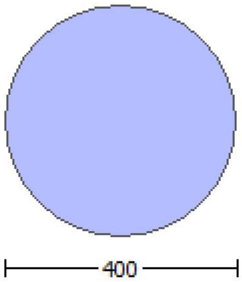
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

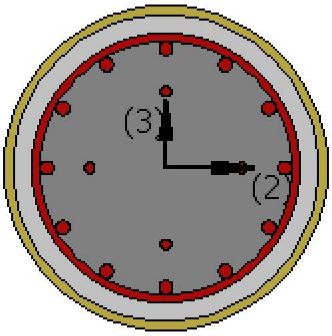
Analysis: Uniform +X

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, κ = 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, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
##################################################################
Note: Especially for the calculation of θy 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, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 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 lo/lou,min =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
-----------------------------------------------------------------
EDGE -A-
Bending Moment, Ma = -1.3625E+007
Shear Force, Va = -4539.895
EDGE -B-
Bending Moment, Mb = 0.03889518
Shear Force, Vb = 4539.895
BOTH EDGES
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,ten = 17.20
-----------------------------------------------------------------
-----------------------------------------------------------------

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 393310.919
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 393310.919
VCol = 393310.919
knl = 1.00
displacement_ductility_demand = 0.09930763
-----------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.03889518
Vu = 4539.895
d = 0.8*D = 320.00
Nu = 4819.292
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 197392.088
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 267132.42
bw*d = π*d*d/4 = 80424.772

---------------------------------------------------------------

---------------------------------------------------------------
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END B -
for rotation axis 3 and integ. section (b)
---------------------------------------------------------------
From analysis, chord rotation θ = 0.00020077
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038064E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48506
error of function (7c) = 0.00456662
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

---------------------------------------------------------------

## Calculation No. 6

column C1, Floor 1

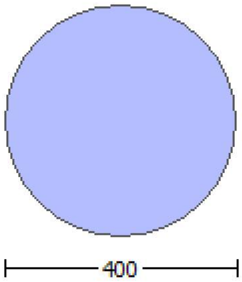
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

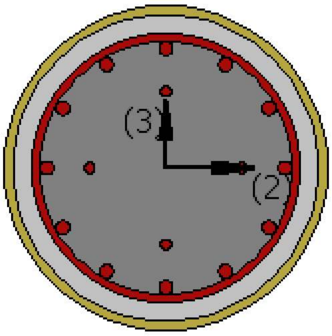
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
######################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-----------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 8.8188366E-032
EDGE -B-
Shear Force, Vb = -8.8188366E-032
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-----------------------------------------------------------
-----------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr  =  0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 =  Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 =  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
-----------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227

--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Mu1-
-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Mu2+
-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Mu2-

--------------------------------------------------------------------------

--------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440

with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
-------------------------------------------------------------------
----------------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
#################################################################

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-----------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -5.3998017E-048
EDGE -B-
Shear Force, Vb = 5.3998017E-048
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-----------------------------------------------------------------
-----------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr  =  0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 =  Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 =  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
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Mu1-
-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Mu2+
-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00

From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56

s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772

---

---

Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

---

λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 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 = 4.2202164E-011
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 θu,R = 1.0*θu = 0.01010841
θu = θy + θp = 0.01010841

---------------------------------------------------------------
- Calculation of θy -

---------------------------------------------------------------
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038064E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48506
error of function (7c) = 0.00456662
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30

---------------------------------------------------------------
- Calculation of θp -
---------------------------------------------------------------
From table 10-9: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.31871182
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf 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
fytE = fylE = 555.56
pl = 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: (b)

-----------------------------------------------------------

## Calculation No. 7

column C1, Floor 1

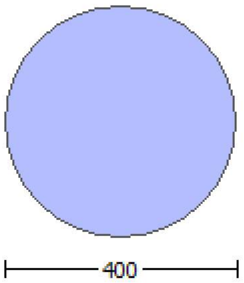
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

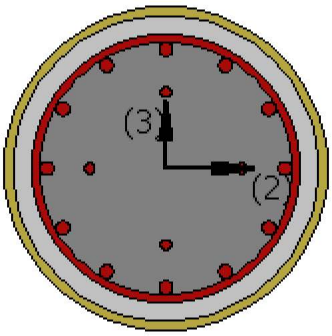
Analysis: Uniform +X

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, κ = 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, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#################################################################
Note: Especially for the calculation of θy 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, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 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 lo/lou,min =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
-------------------------------------------------------------
EDGE -A-
Bending Moment, Ma = 9.0989575E-010
Shear Force, Va = -3.1724095E-013
EDGE -B-
Bending Moment, Mb = 4.2202164E-011
Shear Force, Vb = 3.1724095E-013
BOTH EDGES
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,ten = 17.20
-------------------------------------------------------------
-------------------------------------------------------------

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 393310.919
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 393310.919
VCol = 393310.919
knl = 1.00
displacement_ductility_demand = 0.00
-------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.2202164E-011
Vu = 3.1724095E-013
d = 0.8*D = 320.00
Nu = 4819.292
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 197392.088
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 267132.42
bw*d = π*d*d/4 = 80424.772
----------------------------------------------------------------

----------------------------------------------------------------
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END B -
for rotation axis 2 and integ. section (b)
----------------------------------------------------------------
From analysis, chord rotation θ = 1.1801063E-020
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
----------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038064E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48506
error of function (7c) = 0.00456662
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
----------------------------------------------------------------
----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

-----------------------------------------------------------------

## Calculation No. 8

column C1, Floor 1

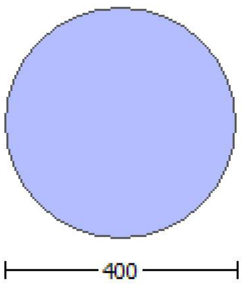
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

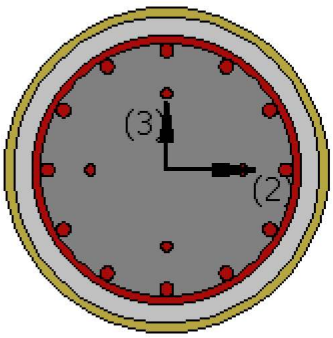
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
#################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 8.8188366E-032
EDGE -B-
Shear Force, Vb = -8.8188366E-032
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-------------------------------------------------------------
-------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
---------------------------------------------------------------------------
φ = 0.9424778

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

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu1-
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00

v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu2-
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
---------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134

ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
----------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
##################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-----------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -5.3998017E-048
EDGE -B-
Shear Force, Vb = 5.3998017E-048
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-----------------------------------------------------------------
-----------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr  =  0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 =  Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu1-
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

Calculation of Mu2+

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

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

--------------------------------------------------------------------------------

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

----------------------------------------------------------------

Calculation of ratio lb/ld

----------------------------------------------------------------

Inadequate Lap Length with lb/ld = 0.30

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

Calculation of Mu2-

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

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

--------------------------------------------------------------------------------

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

----------------------------------------------------------------

Calculation of ratio lb/ld

----------------------------------------------------------------

Inadequate Lap Length with lb/ld = 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+ψf*Vf'

where Vf is the contribution of FRPs (11.3), ACI 440).
----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
----------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 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 = 0.03889518
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 θu,R = 1.0*θu = 0.00202168
θu = θy + θp = 0.00202168

---------------------------------------------------------------
- Calculation of θy -
---------------------------------------------------------------
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038064E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48506
error of function (7c) = 0.00456662
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101203
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30

---------------------------------------------------------------
- Calculation of θp -
---------------------------------------------------------------
From table 10-9: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 0.31871182
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00

Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf 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
fytE = fylE = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.0292
f'cE = 33.00
-------------------------------------------------------------
End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

-------------------------------------------------------------

## Calculation No. 9

column C1, Floor 1

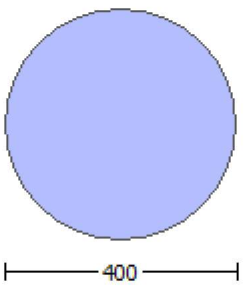
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

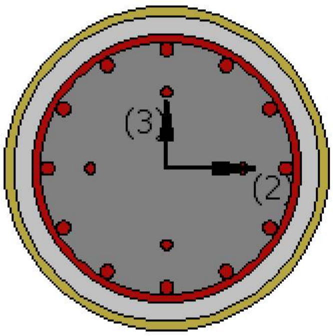
Analysis: Uniform +X

Check: Shear capacity 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, κ = 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, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
################################################################
Note: Especially for the calculation of θy 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, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 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 lo/lou,min =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
---------------------------------------------------------------
EDGE -A-
Bending Moment, Ma = -8.6091E+006
Shear Force, Va = -2868.587
EDGE -B-
Bending Moment, Mb = 0.02457639
Shear Force, Vb = 2868.587
BOTH EDGES
Axial Force, F = -4819.961
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1426.283
-Compression: Aslc = 2243.097
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,ten = 17.20
---------------------------------------------------------------
---------------------------------------------------------------

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 330221.736
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 330221.736
VCol = 330221.736
knl = 1.00
displacement_ductility_demand = 0.0113736
---------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
---------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00

Mu = 8.6091E+006
Vu = 2868.587
d = 0.8*D = 320.00
Nu = 4819.961
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 197392.088
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 267132.42
bw*d = π*d*d/4 = 80424.772
---------------------------------------------------------------

---------------------------------------------------------------
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -
for rotation axis 3 and integ. section (a)
---------------------------------------------------------------
From analysis, chord rotation θ = 0.00023003
θy = (My*Ls/3)/EIeff = 0.02022462 ((4.29),Biskinis Phd))
My = 2.0578E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.156
From table 10.5, ASCE 41_17: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038084E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48507
error of function (7c) = 0.00456648
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
-------------------------------------------------------------------
-------------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-------------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

-------------------------------------------------------------------

## Calculation No. 10

column C1, Floor 1

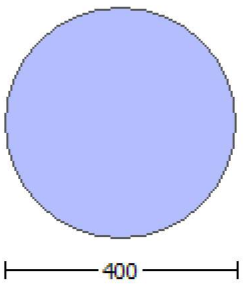
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

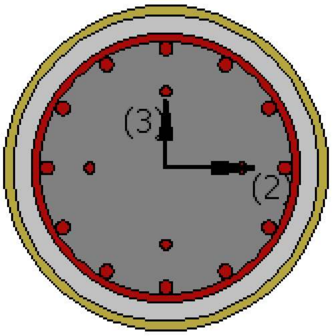
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
#################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-----------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 8.8188366E-032
EDGE -B-
Shear Force, Vb = -8.8188366E-032
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-----------------------------------------------------------------
-----------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu1-
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------------------

---------------------------------------------------------------------------

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------
--------------------------------------------------------------------------
--------------------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------------------

--------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772

-----------------------------------------------------------------

--------------------------------------------------------------------------------

Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

-----------------------------------------------------------------

λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440

with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
#################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
---------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -5.3998017E-048
EDGE -B-
Shear Force, Vb = 5.3998017E-048
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu1-
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00

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

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu2-
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------

Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56

s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 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 = 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: Aslt = 1426.283
-Compression: Aslc = 2243.097
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 θu,R = 1.0*θu = 0.04010842
θu = θy + θp = 0.04010842

---------------------------------------------------------------
- Calculation of θy -
---------------------------------------------------------------
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038084E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48507
error of function (7c) = 0.00456648
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of ratio lb/ld

----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30

----------------------------------------------------------------
- Calculation of θp -
----------------------------------------------------------------
From table 10-9: θp = 0.03
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.31871182
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf 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 = fylE = 555.56
pl = 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. 11

column C1, Floor 1

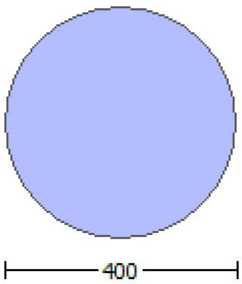
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

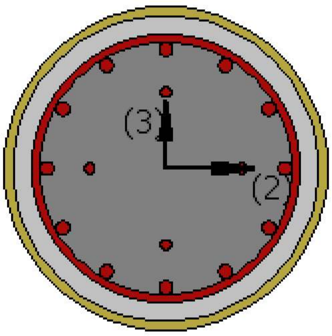
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



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

Constant Properties
---------------------------------------------------------------
Knowledge Factor, κ = 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, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
################################################################
Note: Especially for the calculation of θy 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, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 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 lo/lou,min =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
---------------------------------------------------------------
EDGE -A-
Bending Moment, Ma = 5.7912052E-010
Shear Force, Va = -2.0045250E-013
EDGE -B-
Bending Moment, Mb = 2.2473986E-011
Shear Force, Vb = 2.0045250E-013
BOTH EDGES
Axial Force, F = -4819.961
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1426.283
-Compression: Aslc = 2243.097
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,ten = 17.20
---------------------------------------------------------------
---------------------------------------------------------------

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 393311.051
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 393311.051
VCol = 393311.051
knl = 1.00
displacement_ductility_demand = 0.00
---------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
---------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.7912052E-010
Vu = 2.0045250E-013
d = 0.8*D = 320.00
Nu = 4819.961
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 197392.088
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 267132.42
bw*d = π*d*d/4 = 80424.772
---------------------------------------------------------------

---------------------------------------------------------------
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -
for rotation axis 2 and integ. section (a)
---------------------------------------------------------------
From analysis, chord rotation θ = 1.6445157E-020
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008

Φy = 9.1038084E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48507
error of function (7c) = 0.00456648
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
--------------------------------------------------------------
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

--------------------------------------------------------------

## Calculation No. 12

column C1, Floor 1

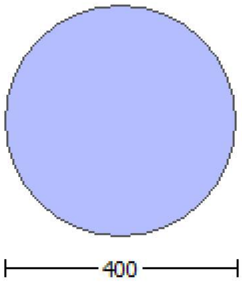
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

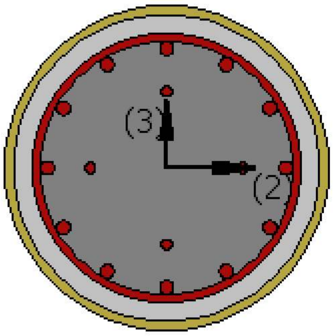
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
#################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
---------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 8.8188366E-032
EDGE -B-
Shear Force, Vb = -8.8188366E-032
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
----------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-------------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
Calculation of Mu1-
----------------------------------------------------------------------------------

----------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
----------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406

fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2-
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227

----------------------------------------------------------------

Calculation of ratio lb/ld

----------------------------------------------------------------

Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

----------------------------------------------------------------

λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772

----------------------------------------------------------------
--------------------------------------------------------------------------------

Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

----------------------------------------------------------------

λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109

Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -5.3998017E-048
EDGE -B-
Shear Force, Vb = 5.3998017E-048
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-------------------------------------------------------------
-------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-------------------------------------------------------------

Calculation of ratio lb/ld

---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu1-
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu2-
------------------------------------------------------------------------------

------------------------------------------------------------------------------

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
---------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772

---------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
---------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 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 = -8.6091E+006
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 = 1426.283
-Compression: Aslc = 2243.097
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 θu,R = 1.0*θu = 0.05022462
θu = θy + θp = 0.05022462

-----------------------------------------------------------------
- Calculation of θy -
-----------------------------------------------------------------
θy = (My*Ls/3)/EIeff = 0.02022462 ((4.29),Biskinis Phd))
My = 2.0578E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.156
From table 10.5, ASCE 41_17: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
-----------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038084E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48507
error of function (7c) = 0.00456648
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101202

with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30

---------------------------------------------------------------
- Calculation of θp -
---------------------------------------------------------------
From table 10-9: θp = 0.03
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.31871182
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf 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 = fylE = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.0292
f'cE = 33.00
---------------------------------------------------------------
End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

---------------------------------------------------------------

## Calculation No. 13

column C1, Floor 1

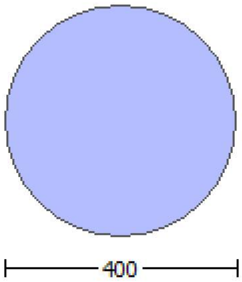
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

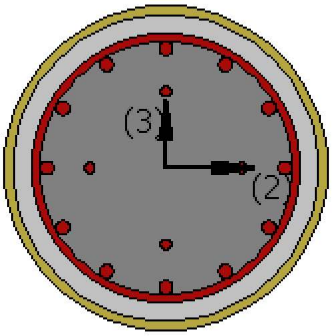
Analysis: Uniform +X

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, κ = 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, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
####################################################################
Note: Especially for the calculation of θy 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, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 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 lo/lou,min =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
-----------------------------------------------------------------
EDGE -A-
Bending Moment, Ma = -8.6091E+006
Shear Force, Va = -2868.587
EDGE -B-
Bending Moment, Mb = 0.02457639
Shear Force, Vb = 2868.587
BOTH EDGES
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,ten = 17.20
-----------------------------------------------------------------
-----------------------------------------------------------------

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 393311.051
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 393311.051
VCol = 393311.051
knl = 1.00
displacement_ductility_demand = 0.06274869
-----------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.02457639
Vu = 2868.587
d = 0.8*D = 320.00
Nu = 4819.961
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 197392.088
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 267132.42
bw*d = π*d*d/4 = 80424.772

---------------------------------------------------------------

---------------------------------------------------------------
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END B -
for rotation axis 3 and integ. section (b)
---------------------------------------------------------------
From analysis, chord rotation θ = 0.00012686
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038084E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48507
error of function (7c) = 0.00456648
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

---------------------------------------------------------------

# Calculation No. 14

column C1, Floor 1

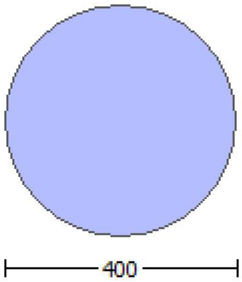
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

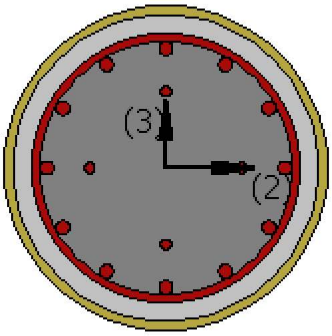
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
##################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
----------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 8.8188366E-032
EDGE -B-
Shear Force, Vb = -8.8188366E-032
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
----------------------------------------------------------------
----------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227

---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu1-
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------------------------

------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------------------
------------------------------------------------------------------------------
------------------------------------------------------------------------------
Calculation of Mu2-

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440

with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
-------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
################################################################

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -5.3998017E-048
EDGE -B-
Shear Force, Vb = 5.3998017E-048
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-------------------------------------------------------------
-------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Mu1-
-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Mu2+
-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00

From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56

s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
---------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
---------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 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 = 2.2473986E-011
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 θu,R = 1.0*θu = 0.04010842
θu = θy + θp = 0.04010842

---------------------------------------------------------------
- Calculation of θy -
---------------------------------------------------------------
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038084E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48507
error of function (7c) = 0.00456648
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30

---------------------------------------------------------------
- Calculation of θp -
---------------------------------------------------------------
From table 10-9: θp = 0.03
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.31871182
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf 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 = fylE = 555.56
pl = 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: (b)

-----------------------------------------------------------

## Calculation No. 15

column C1, Floor 1

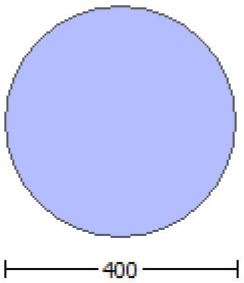
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

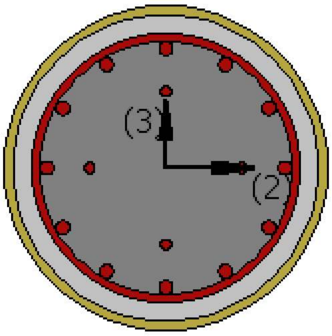
Analysis: Uniform +X

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, κ = 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, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#################################################################
Note: Especially for the calculation of θy 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, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 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 lo/lou,min =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
-------------------------------------------------------------
EDGE -A-
Bending Moment, Ma = 5.7912052E-010
Shear Force, Va = -2.0045250E-013
EDGE -B-
Bending Moment, Mb = 2.2473986E-011
Shear Force, Vb = 2.0045250E-013
BOTH EDGES
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,ten = 17.20
-------------------------------------------------------------
-------------------------------------------------------------

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 393311.051
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 393311.051
VCol = 393311.051
knl = 1.00
displacement_ductility_demand = 0.00
-------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.2473986E-011
Vu = 2.0045250E-013
d = 0.8*D = 320.00
Nu = 4819.961
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 197392.088
Av = π/2*A_stirrup = 123370.055
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 267132.42
bw*d = π*d*d/4 = 80424.772
-----------------------------------------------------------------

-----------------------------------------------------------------
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END B -
for rotation axis 2 and integ. section (b)
-----------------------------------------------------------------
From analysis, chord rotation θ = 7.4566431E-021
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
-----------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038084E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48507
error of function (7c) = 0.00456648
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
-----------------------------------------------------------------
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

-----------------------------------------------------------------

## Calculation No. 16

column C1, Floor 1

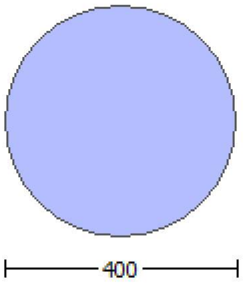
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

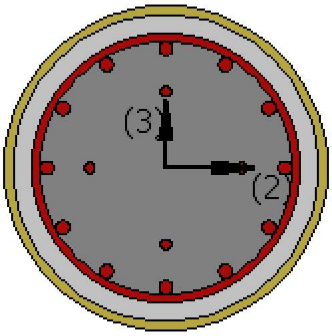
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
#################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
-------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 8.8188366E-032
EDGE -B-
Shear Force, Vb = -8.8188366E-032
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
-------------------------------------------------------------
-------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr  =  0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 =  Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 =  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
-----------------------------------------------------------------------------
φ = 0.9424778

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

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu1-
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu2+
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00

v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Calculation of Mu2-
-------------------------------------------------------------------------------

-------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
----------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134

ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
---------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
---------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.1386922E-011
Vu = 8.8188366E-032
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 1.00
Mean strength values are used for both shear and moment calculations.
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
################################################################
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
New material: Steel Strength, fs = 1.25*fsm = 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 lo/lou,min = 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
---------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -5.3998017E-048
EDGE -B-
Shear Force, Vb = 5.3998017E-048
BOTH EDGES
Axial Force, F = -4821.109
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3669.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1223.127
-Compression: Asl,com = 1223.127
-Middle: Asl,mid = 1223.127
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of Shear Capacity ratio , Ve/Vr = 0.31871182
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 143974.143
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.1596E+008
Mu1+ = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

Mu1- = 2.1596E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = 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
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu1-
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
--------------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

Calculation of Mu2+
-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
Calculation of Mu2-
-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.1596E+008
-----------------------------------------------------------------------------
φ = 0.9424778
φ' = 0.8362801
error of function (3.68), Biskinis Phd = 53851.649
From 5A.2, TBDY: fcc = fc*λc = 51.61391
conf. factor λc = 1.56406
fc = 33.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0139
lb/ld = 0.30
d1 = 44.00
R = 200.00
v = 0.00102726
N = 4821.109
Ac = 125663.706
ω = ω*Min(1,1.25*(lb/ld)^2/3) = 0.30415227
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 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+ψf*Vf'

where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*d*d/4 = 80424.772
-------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 451737.695
Vr2 = 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+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
λ = 1 (normal-weight concrete)
fc' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.3208129E-012
Vu = 5.3998017E-048
d = 0.8*D = 320.00
Nu = 4821.109
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 219326.297
Av = π/2*A_stirrup = 123370.055
fy = 555.56
s = 100.00
Vs is multiplied by αCol = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 194961.134
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina 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, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|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
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 306911.784
bw*d = π*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, κ = 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 θu,R = 1.0*θu = 0.03202168
θu = θy + θp = 0.03202168

---------------------------------------------------------------
- Calculation of θy -
---------------------------------------------------------------
θy = (My*Ls/3)/EIeff = 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: EIeff = 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 Φy and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------------
My = Min(My_ten,My_com) = 2.0578E+008
Φy = 9.1038084E-006
My_ten (8c) = 2.0578E+008
Φ_ten (7c) = 69.48507
error of function (7c) = 0.00456648
My_com (8d) = 5.0781E+008
Φ_com (7d) = 68.37715
error of function (7d) = -0.00101202
with ((10.1), ASCE 41-17) ey = 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) ω = Min(ω, 1.25*ω*(lb/ld)^2/3) = 0.4369098
with fc* ((12.3), ACI 440) = 37.12975
fc = 33.00
fl = 1.3173
kα = 1
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
efe ((12.5) and (12.7)) = 0.004
εfu = 0.01
Ef = 64828.00
---------------------------------------------------------------
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30

---------------------------------------------------------------
- Calculation of θp -
---------------------------------------------------------------
From table 10-9: θp = 0.03
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 0.31871182
d = 0.00
s = 0.00
ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00

Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf 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 = fylE = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.0292
f'cE = 33.00
------------------------------------------------------------
End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

------------------------------------------------------------