Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

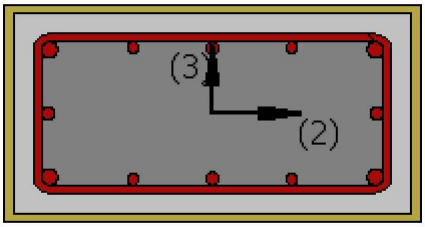
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039

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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Section Height, H = 250.00
Section Width, W = 500.00
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 = -1.1597E+007
Shear Force, Va = -3853.513
EDGE -B-
Bending Moment, Mb = 33515.919
Shear Force, Vb = 3853.513
BOTH EDGES
Axial Force, F = -4772.994
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 316019.354
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 316019.354
VCol = 316019.354
knl = 1.00
displacement_ductility_demand = 0.02801902

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' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.1597E+007
Vu = 3853.513

d = 0.8*h = 400.00
Nu = 4772.994
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 251327.412
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 265721.532
bw = 250.00

---
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 = 0.00019559
θy = (My*Ls/3)/EIeff = 0.00698058 ((4.29),Biskinis Phd))
My = 1.1427E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3009.429
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6421E+013
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4772.994
Ec*Ig = 5.4737E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0111358E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 457.00
ξy = 0.3209156
A = 0.0235957
B = 0.01298394
with pt = 0.00725935
pc = 0.00725935
pv = 0.0089092
N = 4772.994
b = 250.00
δ" = 0.0940919
Φy_comp = 1.1987390E-005
with fc* (12.3, (ACI 440)) = 20.44423
fc = 20.00

fl = 0.9425867
b = 250.00
h = 500.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15033165
ρg = pt + pc + pv = 0.02342789
rc = 40.00
Ae/Ac = 0.60132659
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.31958736
A = 0.02330859
B = 0.01281613
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

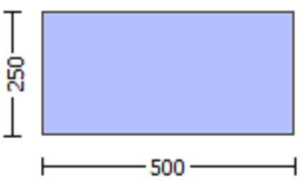
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

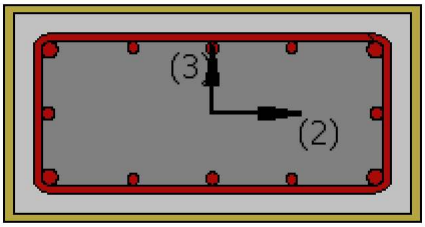
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##########
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = -3.6206709E-031
EDGE -B-
Shear Force, Vb = 3.6206709E-031
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.1467291
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 52248.951
with

Mpr1 = Max(Mu1+ , Mu1-) = 7.8373E+007
Mu1+ = 7.8373E+007, 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- = 7.8373E+007, 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-) = 7.8373E+007
Mu2+ = 7.8373E+007, 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- = 7.8373E+007, 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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00

fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00

ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128

bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056

εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00

h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 356091.268

Calculation of Shear Strength at edge 1, Vr1 = 356091.268
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012

Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 356091.268
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704

bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = 8.5800179E-032
EDGE -B-
Shear Force, Vb = -8.5800179E-032
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805

-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27523624
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 112690.591
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6904E+008
Mu1+ = 1.6904E+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- = 1.6904E+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-) = 1.6904E+008
Mu2+ = 1.6904E+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- = 1.6904E+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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00

Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00

effective stress from (A.35), ff,e = 703.4155

R = 40.00

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

fu,f = 1055.00

Ef = 64828.00

εu,f = 0.015

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

Σbi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

---

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

---

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00339158

λc = confinement factor = 1.13916

εy1 = 0.00129669

εsh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

εy2 = 0.00129669

εsh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

εsu2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

εyv = 0.00129669

εshv = 0.0044814

ftv = 373.4467

fyv = 311.2056

εsuv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669

εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 409432.244

Calculation of Shear Strength at edge 1, Vr1 = 409432.244
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244

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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 409432.244
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
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 = -6.8036747E-011
Shear Force, V2 = -3853.513
Shear Force, V3 = 3.4695601E-014
Axial Force, F = -4772.994
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257

-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00692703
θu = θy + θp = 0.00692703

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00692703 ((4.29),Biskinis Phd))
My = 5.6875E+007
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 = 4.1053E+012
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4772.994
Ec*Ig = 1.3684E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 9.2393283E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 208.00
ξy = 0.35225571
A = 0.02592123
B = 0.01565122
with pt = 0.01093516
pc = 0.01093516
pv = 0.00386658
N = 4772.994
b = 500.00
δ" = 0.20192308
Φy_comp = 2.3973960E-005
with fc* (12.3, (ACI 440)) = 20.44353
fc = 20.00
fl = 0.9425867
b = 500.00
h = 250.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15009543
ρg = pt + pc + pv = 0.02573689
rc = 40.00
Ae/Ac = 0.60038173
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.35108518
A = 0.02560582
B = 0.01546688
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: 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 = 0.1467291
d = 208.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
bw = 500.00
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 = 4772.994
Ag = 125000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02573689
b = 500.00
d = 208.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

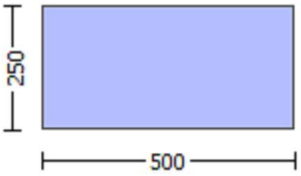
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

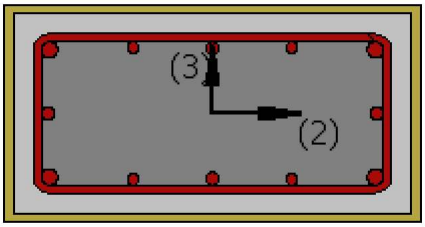
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Section Height, H = 250.00
Section Width, W = 500.00
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 = -6.8036747E-011
Shear Force, Va = 3.4695601E-014
EDGE -B-
Bending Moment, Mb = -3.6047496E-011

Shear Force, Vb = -3.4695601E-014
BOTH EDGES
Axial Force, F = -4772.994
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 330379.134
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 330379.134
VCol = 330379.134
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' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.8036747E-011
Vu = 3.4695601E-014
d = 0.8*h = 200.00
Nu = 4772.994
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 265721.532
bw = 500.00

---
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 = 1.6615983E-022
θy = (My*Ls/3)/EIeff = 0.00692703 ((4.29),Biskinis Phd))
My = 5.6875E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00

From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 4.1053E+012
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4772.994
Ec*Ig = 1.3684E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 9.2393283E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 208.00
ξy = 0.35225571
A = 0.02592123
B = 0.01565122
with pt = 0.01093516
pc = 0.01093516
pv = 0.00386658
N = 4772.994
b = 500.00
δ" = 0.20192308
Φy_comp = 2.3973960E-005
with fc* (12.3, (ACI 440)) = 20.44353
fc = 20.00
fl = 0.9425867
b = 500.00
h = 250.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15009543
ρg = pt + pc + pv = 0.02573689
rc = 40.00
Ae/Ac = 0.60038173
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.35108518
A = 0.02560582
B = 0.01546688
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

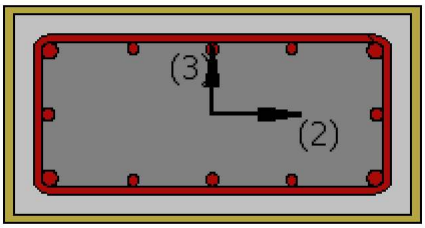
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##########
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = -3.6206709E-031
EDGE -B-
Shear Force, Vb = 3.6206709E-031
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.1467291
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 52248.951
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.8373E+007
Mu1+ = 7.8373E+007, 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- = 7.8373E+007, 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-) = 7.8373E+007
Mu2+ = 7.8373E+007, 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- = 7.8373E+007, 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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902

where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00

d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669

εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702

Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158

λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 356091.268

Calculation of Shear Strength at edge 1, Vr1 = 356091.268
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 356091.268
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268

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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916

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 = 8.5800179E-032
EDGE -B-
Shear Force, Vb = -8.5800179E-032
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27523624
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 112690.591
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6904E+008
Mu1+ = 1.6904E+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- = 1.6904E+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-) = 1.6904E+008
Mu2+ = 1.6904E+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- = 1.6904E+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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00

d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814

ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008

φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00314159
Expression ((5.4d), TBDY) for ρsh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

ρsh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

ρsh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982

No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

---

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

---

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00339158

λc = confinement factor = 1.13916

εy1 = 0.00129669

εsh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

εy2 = 0.00129669

εsh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

εsu2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

εyv = 0.00129669

εshv = 0.0044814

ftv = 373.4467

fyv = 311.2056

εsuv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 409432.244

Calculation of Shear Strength at edge 1, Vr1 = 409432.244
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 409432.244
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
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 = -1.1597E+007
Shear Force, V2 = -3853.513
Shear Force, V3 = 3.4695601E-014
Axial Force, F = -4772.994
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00698058
θu = θy + θp = 0.00698058

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00698058 ((4.29),Biskinis Phd))
My = 1.1427E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3009.429
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6421E+013
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4772.994
Ec*Ig = 5.4737E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0111358E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644

d = 457.00
ξy = 0.3209156
A = 0.0235957
B = 0.01298394
with pt = 0.00725935
pc = 0.00725935
pv = 0.0089092
N = 4772.994
b = 250.00
δ" = 0.0940919
Φy_comp = 1.1987390E-005
with fc* (12.3, (ACI 440)) = 20.44423
fc = 20.00
fl = 0.9425867
b = 250.00
h = 500.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15033165
ρg = pt + pc + pv = 0.02342789
rc = 40.00
Ae/Ac = 0.60132659
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.31958736
A = 0.02330859
B = 0.01281613
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: 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 = 0.27523624
d = 457.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
bw = 250.00
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 = 4772.994
Ag = 125000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02342789
b = 250.00
d = 457.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

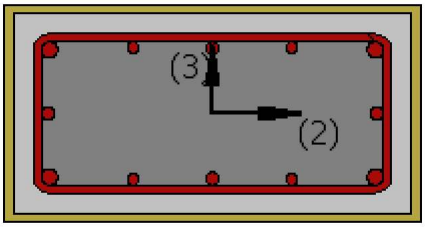
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##########
Section Height, H = 250.00
Section Width, W = 500.00
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 = -1.1597E+007
Shear Force, Va = -3853.513
EDGE -B-
Bending Moment, Mb = 33515.919
Shear Force, Vb = 3853.513
BOTH EDGES
Axial Force, F = -4772.994
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 366317.176
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 366317.176
VCol = 366317.176
knl = 1.00
displacement_ductility_demand = 0.15300225

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' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 33515.919
Vu = 3853.513
d = 0.8*h = 400.00
Nu = 4772.994
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 251327.412
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 265721.532
bw = 250.00

---

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 = 0.00010647
θy = (My*Ls/3)/EIeff = 0.00069587 ((4.29),Biskinis Phd))
My = 1.1427E+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 = 1.6421E+013
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4772.994
Ec*Ig = 5.4737E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0111358E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 457.00
ξy = 0.3209156
A = 0.0235957
B = 0.01298394
with pt = 0.00725935
pc = 0.00725935
pv = 0.0089092
N = 4772.994
b = 250.00
δ" = 0.0940919
Φy_comp = 1.1987390E-005
with fc* (12.3, (ACI 440)) = 20.44423
fc = 20.00
fl = 0.9425867
b = 250.00
h = 500.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15033165
ρg = pt + pc + pv = 0.02342789
rc = 40.00
Ae/Ac = 0.60132659
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.31958736

A = 0.02330859
B = 0.01281613
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

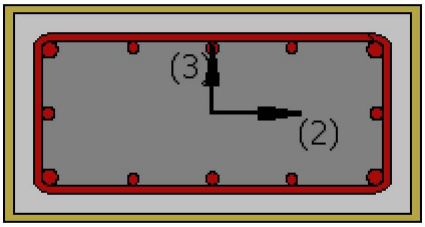
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = -3.6206709E-031
EDGE -B-
Shear Force, Vb = 3.6206709E-031
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.1467291
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 52248.951
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.8373E+007
Mu1+ = 7.8373E+007, 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- = 7.8373E+007, 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-) = 7.8373E+007
Mu2+ = 7.8373E+007, 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- = 7.8373E+007, 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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467

fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00314159
Expression ((5.4d), TBDY) for ρsh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

ρsh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

ρsh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00

bk = 250.00

---

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00339158

λc = confinement factor = 1.13916

εy1 = 0.00129669

εsh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

εy2 = 0.00129669

εsh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

εsu2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

εyv = 0.00129669

εshv = 0.0044814

ftv = 373.4467

fyv = 311.2056

εsuv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499

and confined core properties:

b = 440.00

d = 178.00

d' = 12.00

fcc (5A.2, TBDY) = 22.78316

εcc (5A.5, TBDY) = 0.00339158

λc = confinement factor = 1.13916

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

---

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

---

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

---

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00339158

λc = confinement factor = 1.13916

εy1 = 0.00129669

εsh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

εy2 = 0.00129669

εsh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

εsu2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

εyv = 0.00129669

εshv = 0.0044814

ftv = 373.4467

fyv = 311.2056

εsuv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 356091.268

Calculation of Shear Strength at edge 1, Vr1 = 356091.268
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 356091.268
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = 8.5800179E-032
EDGE -B-
Shear Force, Vb = -8.5800179E-032
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27523624
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 112690.591
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6904E+008
Mu1+ = 1.6904E+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- = 1.6904E+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-) = 1.6904E+008
Mu2+ = 1.6904E+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- = 1.6904E+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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056

with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 409432.244

Calculation of Shear Strength at edge 1, Vr1 = 409432.244
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888

Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 409432.244
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
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 = -3.6047496E-011
Shear Force, V2 = 3853.513
Shear Force, V3 = -3.4695601E-014
Axial Force, F = -4772.994
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00692703
θu = θy + θp = 0.00692703

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00692703 ((4.29),Biskinis Phd))

My = 5.6875E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 4.1053E+012
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4772.994
Ec*Ig = 1.3684E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 9.2393283E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 208.00
ξy = 0.35225571
A = 0.02592123
B = 0.01565122
with pt = 0.01093516
pc = 0.01093516
pv = 0.00386658
N = 4772.994
b = 500.00
δ" = 0.20192308
Φy_comp = 2.3973960E-005
with fc* (12.3, (ACI 440)) = 20.44353
fc = 20.00
fl = 0.9425867
b = 500.00
h = 250.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15009543
ρg = pt + pc + pv = 0.02573689
rc = 40.00
Ae/Ac = 0.60038173
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.35108518
A = 0.02560582
B = 0.01546688
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: 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 = 0.1467291
d = 208.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
bw = 500.00

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 = 4772.994
Ag = 125000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02573689
b = 500.00
d = 208.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

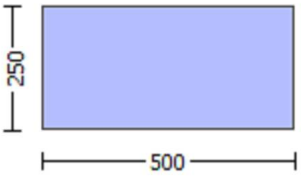
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

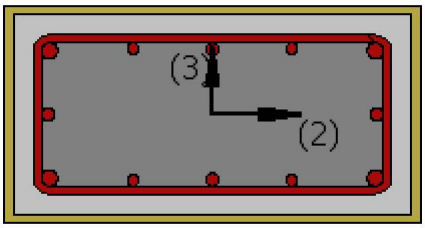
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Section Height, H = 250.00
Section Width, W = 500.00
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 = -6.8036747E-011
Shear Force, Va = 3.4695601E-014
EDGE -B-
Bending Moment, Mb = -3.6047496E-011
Shear Force, Vb = -3.4695601E-014
BOTH EDGES
Axial Force, F = -4772.994
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 330379.134
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 330379.134
VCol = 330379.134
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' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.6047496E-011
Vu = 3.4695601E-014
d = 0.8*h = 200.00
Nu = 4772.994
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 265721.532
bw = 500.00

---
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 = 2.0196095E-022
θy = (My*Ls/3)/EIeff = 0.00692703 ((4.29),Biskinis Phd))
My = 5.6875E+007
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 = 4.1053E+012
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4772.994
Ec*Ig = 1.3684E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 9.2393283E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 208.00
ξy = 0.35225571
A = 0.02592123
B = 0.01565122
with pt = 0.01093516
pc = 0.01093516
pv = 0.00386658
N = 4772.994
b = 500.00

δ" = 0.20192308
Φy_comp = 2.3973960E-005
with fc* (12.3, (ACI 440)) = 20.44353
fc = 20.00
fl = 0.9425867
b = 500.00
h = 250.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15009543
ρg = pt + pc + pv = 0.02573689
rc = 40.00
Ae/Ac = 0.60038173
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.35108518
A = 0.02560582
B = 0.01546688
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

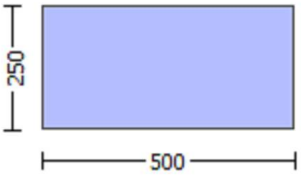
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

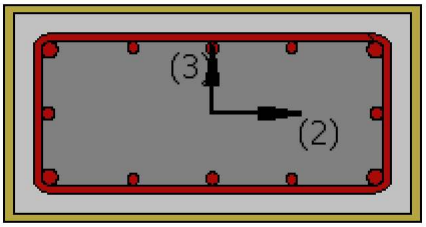
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##########
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = -3.6206709E-031
EDGE -B-
Shear Force, Vb = 3.6206709E-031
BOTH EDGES
Axial Force, F = -4716.808

Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.1467291
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 52248.951
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.8373E+007
Mu1+ = 7.8373E+007, 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- = 7.8373E+007, 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-) = 7.8373E+007
Mu2+ = 7.8373E+007, 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- = 7.8373E+007, 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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056

with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902

where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054

af = 0.45253333

b = 500.00

h = 250.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064

bw = 500.00

effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483

af = 0.45253333

b = 250.00

h = 500.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128

bw = 250.00

effective stress from (A.35), ff,e = 703.4155

R = 40.00

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

fu,f = 1055.00

Ef = 64828.00

εu,f = 0.015

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

Σbi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

---

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

---

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00339158

λc = confinement factor = 1.13916

εy1 = 0.00129669

εsh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

εy2 = 0.00129669

εsh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

εsu2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00

d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 356091.268

Calculation of Shear Strength at edge 1, Vr1 = 356091.268
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 356091.268
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773

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) = 208.00
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 <= 297085.704
bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = 8.5800179E-032
EDGE -B-
Shear Force, Vb = -8.5800179E-032
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27523624
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 112690.591
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6904E+008
Mu1+ = 1.6904E+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- = 1.6904E+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-) = 1.6904E+008
Mu2+ = 1.6904E+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- = 1.6904E+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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483

af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00

εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

```
      ----------------------------------------------------------------------
      ωfx = 0.07705054
         af = 0.45253333
            b = 500.00
            h = 250.00
         From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
            bw = 500.00
         effective stress from (A.35), ff,e = 837.9178
      ----------------------------------------------------------------------
      ωfy = 0.12936483
         af = 0.45253333
            b = 250.00
            h = 500.00
         From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
            bw = 250.00
         effective stress from (A.35), ff,e = 703.4155
      ----------------------------------------------------------------------
         R = 40.00
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
         fu,f = 1055.00
         Ef = 64828.00
         εu,f = 0.015
         ase ((5.4d), TBDY) = 0.05494666
            bo = 440.00
            ho = 190.00
            Σbi2 = 459400.00
         psh,min = Min(psh,x , psh,y) = 0.00314159
      Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without
earthquake detailing (90° closed stirrups)
      ----------------------------------------------------------------------
         psh,x (5.4d) = 0.00314159
            Ash = Astir*ns = 78.53982
               No stirups, ns = 2.00
            bk = 500.00
      ----------------------------------------------------------------------
         psh,y (5.4d) = 0.00628319
            Ash = Astir*ns = 78.53982
               No stirups, ns = 2.00
            bk = 250.00
      ----------------------------------------------------------------------
               s = 100.00
         fywe = 555.55
         fce  = 20.00
      From ((5.A5), TBDY), TBDY: εcc = 0.00339158
         λc  = confinement factor = 1.13916
   εy1 = 0.00129669
   εsh1 = 0.0044814
   ft1 = 373.4467
   fy1 = 311.2056
   εsu1 = 0.00512
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
      and also multiplied by the shear_factor according to 15.7.1.4, with
      Shear_factor = 1.00
      lo/lou,min = lb/ld = 0.30
      εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
      From table 5A.1, TBDY: esu1_nominal = 0.08,
      For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
      characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
      εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
        with fs1 = fs = 311.2056
        with Es1 = Es = 200000.00
   εy2 = 0.00129669
   εsh2 = 0.0044814
   ft2 = 373.4467
   fy2 = 311.2056
   εsu2 = 0.00512
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
```

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00

d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814

ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008

φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 409432.244

Calculation of Shear Strength at edge 1, Vr1 = 409432.244
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 409432.244
  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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 8.5689464E-013
    Vu = 8.5800179E-032
  d = 0.8*h = 400.00
  Nu = 4716.808
  Ag = 125000.00
  From (11.5.4.8), ACI 318-14: Vs = 279249.888
    Av = 157079.633
    fy = 444.44
    s = 100.00
  Vs is multiplied by αCol = 1.00
    s/d = 0.25
  Vf ((11-3)-(11.4), ACI 440) = 240803.347
  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) = 457.00
  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 <= 297085.704
    bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 409432.244
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 409432.244
  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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 8.5689464E-013
    Vu = 8.5800179E-032
  d = 0.8*h = 400.00

Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
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 = 33515.919
Shear Force, V2 = 3853.513
Shear Force, V3 = -3.4695601E-014
Axial Force, F = -4772.994
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00069587
θu = θy + θp = 0.00069587

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00069587 ((4.29),Biskinis Phd))
My = 1.1427E+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 = 1.6421E+013
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4772.994
Ec*Ig = 5.4737E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0111358E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 457.00
ξy = 0.3209156
A = 0.0235957
B = 0.01298394
with pt = 0.00725935
pc = 0.00725935
pv = 0.0089092
N = 4772.994
b = 250.00
δ" = 0.0940919
Φy_comp = 1.1987390E-005
with fc* (12.3, (ACI 440)) = 20.44423
fc = 20.00
fl = 0.9425867
b = 250.00
h = 500.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15033165
ρg = pt + pc + pv = 0.02342789
rc = 40.00

Ae/Ac = 0.60132659
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.31958736
A = 0.02330859
B = 0.01281613
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: 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 = 0.27523624
d = 457.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
bw = 250.00
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 = 4772.994
Ag = 125000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02342789
b = 250.00
d = 457.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

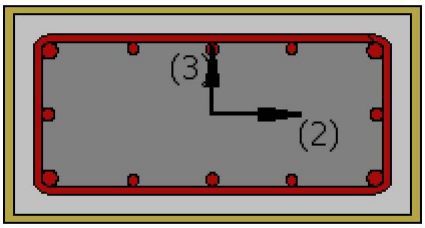
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##########
Section Height, H = 250.00
Section Width, W = 500.00
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 = -7.3539E+006
Shear Force, Va = -2443.62
EDGE -B-
Bending Moment, Mb = 21253.373
Shear Force, Vb = 2443.62
BOTH EDGES
Axial Force, F = -4752.437
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 316017.317
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 316017.317
VCol = 316017.317
knl = 1.00
displacement_ductility_demand = 0.01776819

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' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 7.3539E+006
Vu = 2443.62
d = 0.8*h = 400.00
Nu = 4752.437
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 251327.412
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 265721.532

bw = 250.00

---
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 = 0.00012403
θy = (My*Ls/3)/EIeff = 0.00698037 ((4.29),Biskinis Phd))
My = 1.1427E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3009.429
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6421E+013
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4752.437
Ec*Ig = 5.4737E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0110853E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 457.00
ξy = 0.32090703
A = 0.02359497
B = 0.01298321
with pt = 0.00725935
pc = 0.00725935
pv = 0.0089092
N = 4752.437
b = 250.00
δ" = 0.0940919
Φy_comp = 1.1987499E-005
with fc* (12.3, (ACI 440)) = 20.44423
fc = 20.00
fl = 0.9425867
b = 250.00
h = 500.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15033165
ρg = pt + pc + pv = 0.02342789
rc = 40.00
Ae/Ac = 0.60132659
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.31958447
A = 0.0233091
B = 0.01281613
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

End Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

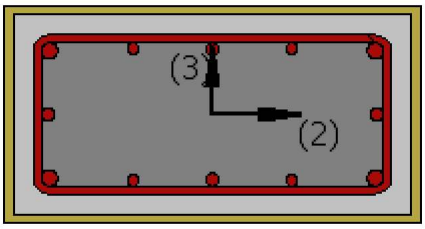
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = -3.6206709E-031
EDGE -B-
Shear Force, Vb = 3.6206709E-031
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.1467291
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 52248.951
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.8373E+007
Mu1+ = 7.8373E+007, 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- = 7.8373E+007, 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-) = 7.8373E+007
Mu2+ = 7.8373E+007, 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- = 7.8373E+007, 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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677

N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056

εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 356091.268

Calculation of Shear Strength at edge 1, Vr1 = 356091.268
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 356091.268
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = 8.5800179E-032
EDGE -B-
Shear Force, Vb = -8.5800179E-032
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27523624
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 112690.591
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6904E+008
Mu1+ = 1.6904E+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- = 1.6904E+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-) = 1.6904E+008
Mu2+ = 1.6904E+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- = 1.6904E+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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---

psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961

and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00

Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 409432.244

Calculation of Shear Strength at edge 1, Vr1 = 409432.244
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 409432.244
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
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 = -4.0780157E-011
Shear Force, V2 = -2443.62
Shear Force, V3 = 2.2001442E-014
Axial Force, F = -4752.437
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03692682
θu = θy + θp = 0.03692682

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00692682 ((4.29),Biskinis Phd))
My = 5.6873E+007
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 = 4.1053E+012
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4752.437
Ec*Ig = 1.3684E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 9.2392118E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 208.00
ξy = 0.35224754
A = 0.02592044
B = 0.01565043
with pt = 0.01093516
pc = 0.01093516
pv = 0.00386658
N = 4752.437
b = 500.00
δ" = 0.20192308
Φy_comp = 2.3974177E-005
with fc* (12.3, (ACI 440)) = 20.44353
fc = 20.00
fl = 0.9425867
b = 500.00
h = 250.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15009543
ρg = pt + pc + pv = 0.02573689
rc = 40.00
Ae/Ac = 0.60038173
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.35108201
A = 0.02560639
B = 0.01546688
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: 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 = 0.1467291
d = 208.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
bw = 500.00
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 = 4752.437
Ag = 125000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02573689
b = 500.00
d = 208.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

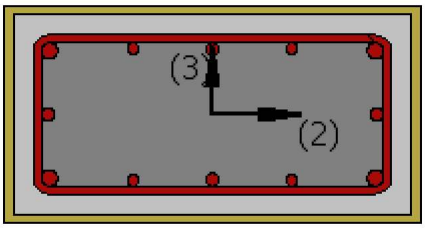
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44

```
#################################################################
Section Height, H = 250.00
Section Width, W = 500.00
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 = -4.0780157E-011
Shear Force, Va = 2.2001442E-014
EDGE -B-
Bending Moment, Mb = -2.5222546E-011
Shear Force, Vb = -2.2001442E-014
BOTH EDGES
Axial Force, F = -4752.437
Longitudinal Reinforcement Area Distribution (in 2 divisions)
          -Tension: Aslt = 0.00
      -Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
          -Tension: Asl,ten = 1137.257
      -Compression: Asl,com = 1137.257
           -Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80
----------------------------------------------------------------
----------------------------------------------------------------


Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 330375.062
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 330375.062
   VCol = 330375.062
   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' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 4.0780157E-011
      Vu = 2.2001442E-014
    d = 0.8*h = 200.00
    Nu = 4752.437
    Ag = 125000.00
    From (11.5.4.8), ACI 318-14: Vs = 125663.706
      Av = 157079.633
      fy = 400.00
      s = 100.00
```

Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 265721.532
bw = 500.00

---

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 = 1.0536655E-022
θy = (My*Ls/3)/EIeff = 0.00692682 ((4.29),Biskinis Phd))
My = 5.6873E+007
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 = 4.1053E+012
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4752.437
Ec*Ig = 1.3684E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 9.2392118E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 208.00
ξy = 0.35224754
A = 0.02592044
B = 0.01565043
with pt = 0.01093516
pc = 0.01093516
pv = 0.00386658
N = 4752.437
b = 500.00
δ" = 0.20192308
Φy_comp = 2.3974177E-005
with fc* (12.3, (ACI 440)) = 20.44353
fc = 20.00
fl = 0.9425867
b = 500.00
h = 250.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15009543
ρg = pt + pc + pv = 0.02573689
rc = 40.00

Ae/Ac = 0.60038173
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.35108201
A = 0.02560639
B = 0.01546688
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

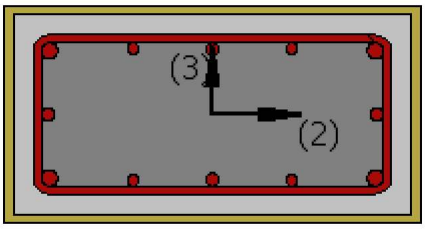
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = -3.6206709E-031
EDGE -B-
Shear Force, Vb = 3.6206709E-031
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.1467291
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 52248.951
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.8373E+007
Mu1+ = 7.8373E+007, 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- = 7.8373E+007, 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-) = 7.8373E+007
Mu2+ = 7.8373E+007, 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- = 7.8373E+007, 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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00314159
Expression ((5.4d), TBDY) for ρsh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

ρsh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

ρsh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00

fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture

δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:

b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00

εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

```
      considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
      For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
      characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
      εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
        with fsv = fs = 311.2056
        with Esv = Es = 200000.00
  ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
  ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
  ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
  b = 440.00
  d = 178.00
  d' = 12.00
  fcc (5A.2, TBDY) = 22.78316
  εcc (5A.5, TBDY) = 0.00339158
     λc  = confinement factor = 1.13916
  ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
  ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
  ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005
------------------------------------------------------------

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


------------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
------------------------------------------------------------------------------
with full section properties:
  b = 500.00
  d = 208.00
  d' = 42.00
  v = 0.0022677
     N = 4716.808
  fc = 20.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.01470636
     ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
     where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
     ---------------------------------------------------------------
     ωfx = 0.07705054
        af = 0.45253333
           b = 500.00
           h = 250.00
        From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
           bw = 500.00
        effective stress from (A.35), ff,e = 837.9178
     ---------------------------------------------------------------
     ωfy = 0.12936483
        af = 0.45253333
```

b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669

εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 356091.268

Calculation of Shear Strength at edge 1, Vr1 = 356091.268
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44

s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 356091.268
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##########
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = 8.5800179E-032
EDGE -B-
Shear Force, Vb = -8.5800179E-032
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27523624
Member Controlled by Flexure (Ve/Vr < 1)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 112690.591
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6904E+008
Mu1+ = 1.6904E+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- = 1.6904E+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-) = 1.6904E+008
Mu2+ = 1.6904E+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- = 1.6904E+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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982

No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00

d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015

ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

```
      For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
      characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
      εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
        with fsv = fs = 311.2056
        with Esv = Es = 200000.00
   ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
   b = 190.00
   d = 427.00
   d' = 13.00
   fcc (5A.2, TBDY) = 22.78316
   εcc (5A.5, TBDY) = 0.00339158
      λc  = confinement factor = 1.13916
   ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005
------------------------------------------------------------

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


------------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
------------------------------------------------------------------------------
with full section properties:
   b = 250.00
   d = 457.00
   d' = 43.00
   v = 0.00206425
      N = 4716.808
   fc = 20.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
      The Shear_factor is considered equal to 1 (pure moment strength)
      From (5.4b), TBDY: εcu = 0.01470636
      ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
      where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
      ---------------------------------------------------------------------
      ωfx = 0.07705054
         af = 0.45253333
            b = 500.00
            h = 250.00
         From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
            bw = 500.00
         effective stress from (A.35), ff,e = 837.9178
      ---------------------------------------------------------------------
      ωfy = 0.12936483
         af = 0.45253333
            b = 250.00
```

h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814

ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054

af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 409432.244

Calculation of Shear Strength at edge 1, Vr1 = 409432.244
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 409432.244
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
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 = -7.3539E+006
Shear Force, V2 = -2443.62
Shear Force, V3 = 2.2001442E-014
Axial Force, F = -4752.437
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03698037
θu = θy + θp = 0.03698037

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00698037 ((4.29),Biskinis Phd))
My = 1.1427E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3009.429
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6421E+013
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4752.437
Ec*Ig = 5.4737E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0110853E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 457.00
ξy = 0.32090703
A = 0.02359497
B = 0.01298321
with pt = 0.00725935
pc = 0.00725935
pv = 0.0089092
N = 4752.437
b = 250.00
δ" = 0.0940919
Φy_comp = 1.1987499E-005
with fc* (12.3, (ACI 440)) = 20.44423
fc = 20.00
fl = 0.9425867
b = 250.00
h = 500.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15033165
ρg = pt + pc + pv = 0.02342789
rc = 40.00
Ae/Ac = 0.60132659
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.31958447
A = 0.0233091
B = 0.01281613
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: 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 = 0.27523624
d = 457.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
bw = 250.00
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 = 4752.437
Ag = 125000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02342789
b = 250.00
d = 457.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

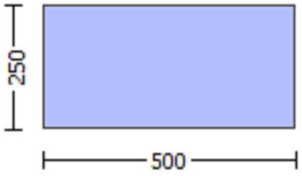
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

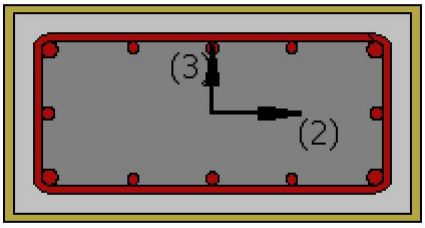
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Section Height, H = 250.00
Section Width, W = 500.00
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 = -7.3539E+006
Shear Force, Va = -2443.62
EDGE -B-
Bending Moment, Mb = 21253.373
Shear Force, Vb = 2443.62
BOTH EDGES
Axial Force, F = -4752.437
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 366313.103
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 366313.103
VCol = 366313.103

knl = 1.00
displacement_ductility_demand = 0.097026

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' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 21253.373
Vu = 2443.62
d = 0.8*h = 400.00
Nu = 4752.437
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 251327.412
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 265721.532
bw = 250.00

---
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 = 6.7515496E-005
θy = (My*Ls/3)/EIeff = 0.00069585 ((4.29),Biskinis Phd))
My = 1.1427E+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 = 1.6421E+013
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4752.437
Ec*Ig = 5.4737E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0110853E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 457.00
ξy = 0.32090703

A = 0.02359497
B = 0.01298321
with pt = 0.00725935
pc = 0.00725935
pv = 0.0089092
N = 4752.437
b = 250.00
δ" = 0.0940919
Φy_comp = 1.1987499E-005
with fc* (12.3, (ACI 440)) = 20.44423
fc = 20.00
fl = 0.9425867
b = 250.00
h = 500.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15033165
ρg = pt + pc + pv = 0.02342789
rc = 40.00
Ae/Ac = 0.60132659
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.31958447
A = 0.0233091
B = 0.01281613
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

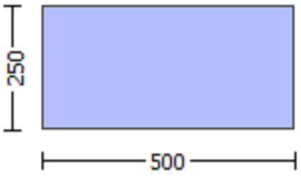
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

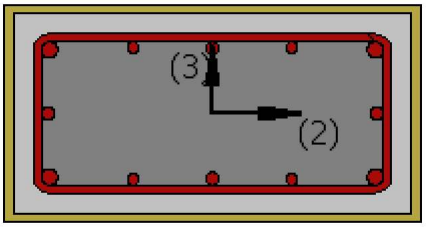
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##########
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = -3.6206709E-031
EDGE -B-
Shear Force, Vb = 3.6206709E-031
BOTH EDGES
Axial Force, F = -4716.808

Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.1467291
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 52248.951
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.8373E+007
Mu1+ = 7.8373E+007, 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- = 7.8373E+007, 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-) = 7.8373E+007
Mu2+ = 7.8373E+007, 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- = 7.8373E+007, 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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056

with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902

where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054

af = 0.45253333

b = 500.00

h = 250.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064

bw = 500.00

effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483

af = 0.45253333

b = 250.00

h = 500.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128

bw = 250.00

effective stress from (A.35), ff,e = 703.4155

R = 40.00

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016

fu,f = 1055.00

Ef = 64828.00

εu,f = 0.015

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

Σbi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

---

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

---

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00339158

λc = confinement factor = 1.13916

εy1 = 0.00129669

εsh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

εy2 = 0.00129669

εsh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

εsu2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00

d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 356091.268

Calculation of Shear Strength at edge 1, Vr1 = 356091.268
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 356091.268
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773

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) = 208.00
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 <= 297085.704
bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = 8.5800179E-032
EDGE -B-
Shear Force, Vb = -8.5800179E-032
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27523624
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 112690.591
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6904E+008
Mu1+ = 1.6904E+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- = 1.6904E+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-) = 1.6904E+008
Mu2+ = 1.6904E+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- = 1.6904E+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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483

af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00

εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

```
      ----------------------------------------------------------------------
      ωfx = 0.07705054
         af = 0.45253333
            b = 500.00
            h = 250.00
         From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
            bw = 500.00
         effective stress from (A.35), ff,e = 837.9178
      ----------------------------------------------------------------------
      ωfy = 0.12936483
         af = 0.45253333
            b = 250.00
            h = 500.00
         From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
            bw = 250.00
         effective stress from (A.35), ff,e = 703.4155
      ----------------------------------------------------------------------
         R = 40.00
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
         fu,f = 1055.00
         Ef = 64828.00
         εu,f = 0.015
         ase ((5.4d), TBDY) = 0.05494666
            bo = 440.00
            ho = 190.00
            Σbi2 = 459400.00
         psh,min = Min(psh,x , psh,y) = 0.00314159
      Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without
earthquake detailing (90° closed stirrups)
      ----------------------------------------------------------------------
         psh,x (5.4d) = 0.00314159
            Ash = Astir*ns = 78.53982
               No stirups, ns = 2.00
            bk = 500.00
      ----------------------------------------------------------------------
         psh,y (5.4d) = 0.00628319
            Ash = Astir*ns = 78.53982
               No stirups, ns = 2.00
            bk = 250.00
      ----------------------------------------------------------------------
               s = 100.00
         fywe = 555.55
         fce  = 20.00
      From ((5.A5), TBDY), TBDY: εcc = 0.00339158
         λc  = confinement factor = 1.13916
   εy1 = 0.00129669
   εsh1 = 0.0044814
   ft1 = 373.4467
   fy1 = 311.2056
   εsu1 = 0.00512
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
      and also multiplied by the shear_factor according to 15.7.1.4, with
      Shear_factor = 1.00
      lo/lou,min = lb/ld = 0.30
      εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
      From table 5A.1, TBDY: esu1_nominal = 0.08,
      For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
      characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
      εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
        with fs1 = fs = 311.2056
        with Es1 = Es = 200000.00
   εy2 = 0.00129669
   εsh2 = 0.0044814
   ft2 = 373.4467
   fy2 = 311.2056
   εsu2 = 0.00512
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
```

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00

d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814

ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008

φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 409432.244

Calculation of Shear Strength at edge 1, Vr1 = 409432.244
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 409432.244
  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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 8.5689464E-013
    Vu = 8.5800179E-032
  d = 0.8*h = 400.00
  Nu = 4716.808
  Ag = 125000.00
  From (11.5.4.8), ACI 318-14: Vs = 279249.888
    Av = 157079.633
    fy = 444.44
    s = 100.00
  Vs is multiplied by αCol = 1.00
    s/d = 0.25
  Vf ((11-3)-(11.4), ACI 440) = 240803.347
  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) = 457.00
  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 <= 297085.704
    bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 409432.244
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 409432.244
  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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 8.5689464E-013
    Vu = 8.5800179E-032
  d = 0.8*h = 400.00

Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
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 = -2.5222546E-011
Shear Force, V2 = 2443.62
Shear Force, V3 = -2.2001442E-014
Axial Force, F = -4752.437
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03692682
θu = θy + θp = 0.03692682

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00692682 ((4.29),Biskinis Phd))
My = 5.6873E+007
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 = 4.1053E+012
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4752.437
Ec*Ig = 1.3684E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 9.2392118E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 208.00
ξy = 0.35224754
A = 0.02592044
B = 0.01565043
with pt = 0.01093516
pc = 0.01093516
pv = 0.00386658
N = 4752.437
b = 500.00
δ" = 0.20192308
Φy_comp = 2.3974177E-005
with fc* (12.3, (ACI 440)) = 20.44353
fc = 20.00
fl = 0.9425867
b = 500.00
h = 250.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15009543
ρg = pt + pc + pv = 0.02573689
rc = 40.00

Ae/Ac = 0.60038173
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.35108201
A = 0.02560639
B = 0.01546688
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: 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 = 0.1467291
d = 208.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
bw = 500.00
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 = 4752.437
Ag = 125000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02573689
b = 500.00
d = 208.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

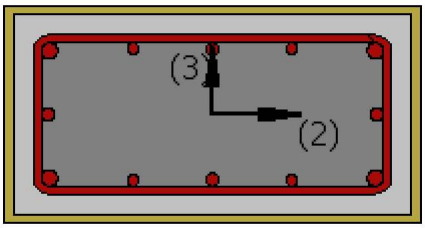
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
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).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Section Height, H = 250.00
Section Width, W = 500.00
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 = -4.0780157E-011
Shear Force, Va = 2.2001442E-014
EDGE -B-
Bending Moment, Mb = -2.5222546E-011
Shear Force, Vb = -2.2001442E-014
BOTH EDGES
Axial Force, F = -4752.437
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 330375.062
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 330375.062
VCol = 330375.062
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' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.5222546E-011
Vu = 2.2001442E-014
d = 0.8*h = 200.00
Nu = 4752.437
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 265721.532

bw = 500.00

---
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 = 1.2806903E-022
θy = (My*Ls/3)/EIeff = 0.00692682 ((4.29),Biskinis Phd))
My = 5.6873E+007
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 = 4.1053E+012
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4752.437
Ec*Ig = 1.3684E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 9.2392118E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 208.00
ξy = 0.35224754
A = 0.02592044
B = 0.01565043
with pt = 0.01093516
pc = 0.01093516
pv = 0.00386658
N = 4752.437
b = 500.00
δ" = 0.20192308
Φy_comp = 2.3974177E-005
with fc* (12.3, (ACI 440)) = 20.44353
fc = 20.00
fl = 0.9425867
b = 500.00
h = 250.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15009543
ρg = pt + pc + pv = 0.02573689
rc = 40.00
Ae/Ac = 0.60038173
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.35108201
A = 0.02560639
B = 0.01546688
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

End Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

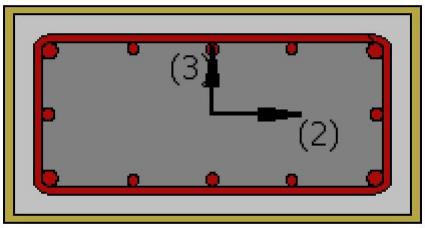
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = -3.6206709E-031
EDGE -B-
Shear Force, Vb = 3.6206709E-031
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.1467291
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 52248.951
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.8373E+007
Mu1+ = 7.8373E+007, 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- = 7.8373E+007, 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-) = 7.8373E+007
Mu2+ = 7.8373E+007, 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- = 7.8373E+007, 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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677

N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056

εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 3.3776478E-005
Mu = 7.8373E+007
---
with full section properties:
b = 500.00
d = 208.00
d' = 42.00
v = 0.0022677
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.17015411
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17015411

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06016499
and confined core properties:
b = 440.00
d = 178.00
d' = 12.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.22594519
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.22594519
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07989222
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.27122702
Mu = MRc (4.14) = 7.8373E+007
φu = φsu (4.1) = 3.3776478E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 356091.268

Calculation of Shear Strength at edge 1, Vr1 = 356091.268
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 356091.268
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 356091.268
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.4608054E-012
Vu = 3.6206709E-031
d = 0.8*h = 200.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 109599.773
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) = 208.00
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 <= 297085.704
bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
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
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.13916
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 = 8.5800179E-032
EDGE -B-
Shear Force, Vb = -8.5800179E-032
BOTH EDGES
Axial Force, F = -4716.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27523624
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 112690.591
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6904E+008
Mu1+ = 1.6904E+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- = 1.6904E+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-) = 1.6904E+008
Mu2+ = 1.6904E+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- = 1.6904E+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 curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---

psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961

and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.4516822E-005
Mu = 1.6904E+008
---
with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00206425
N = 4716.808
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01470636
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01470636
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07848902
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.07705054
af = 0.45253333
b = 500.00
h = 250.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.004064
bw = 500.00
effective stress from (A.35), ff,e = 837.9178

ωfy = 0.12936483
af = 0.45253333
b = 250.00
h = 500.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00

Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
Σbi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
---
psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
---
psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00
---
s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00339158
λc = confinement factor = 1.13916
εy1 = 0.00129669
εsh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2056
with Es1 = Es = 200000.00
εy2 = 0.00129669
εsh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2056
with Es2 = Es = 200000.00
εyv = 0.00129669
εshv = 0.0044814
ftv = 373.4467
fyv = 311.2056
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2056
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.13862961
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 22.78316
εcc (5A.5, TBDY) = 0.00339158
λc = confinement factor = 1.13916
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.19522289
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2282401
Mu = MRc (4.14) = 1.6904E+008
φu = φsu (4.1) = 1.4516822E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 409432.244

Calculation of Shear Strength at edge 1, Vr1 = 409432.244
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 409432.244
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 409432.244
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' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.5689464E-013
Vu = 8.5800179E-032
d = 0.8*h = 400.00
Nu = 4716.808
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 240803.347
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) = 457.00
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 <= 297085.704
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcrs

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:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
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 = 21253.373
Shear Force, V2 = 2443.62
Shear Force, V3 = -2.2001442E-014
Axial Force, F = -4752.437
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03069585
θu = θy + θp = 0.03069585

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00069585 ((4.29),Biskinis Phd))
My = 1.1427E+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 = 1.6421E+013
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4752.437
Ec*Ig = 5.4737E+013

Calculation of Yielding Moment My

Calculation of Φy and My according to Annex 7A - ΚΑΝΕΠΕ

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0110853E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9644
d = 457.00
ξy = 0.32090703
A = 0.02359497
B = 0.01298321
with pt = 0.00725935
pc = 0.00725935
pv = 0.0089092
N = 4752.437
b = 250.00
δ" = 0.0940919
Φy_comp = 1.1987499E-005
with fc* (12.3, (ACI 440)) = 20.44423
fc = 20.00
fl = 0.9425867
b = 250.00
h = 500.00
Ag = 125000.00
From (12.9), ACI 440: ka = 0.15033165
ρg = pt + pc + pv = 0.02342789
rc = 40.00
Ae/Ac = 0.60132659
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.31958447
A = 0.0233091
B = 0.01281613
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: 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 = 0.27523624
d = 457.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
bw = 250.00
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 = 4752.437
Ag = 125000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02342789
b = 250.00
d = 457.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)