Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

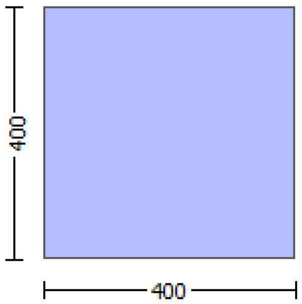
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

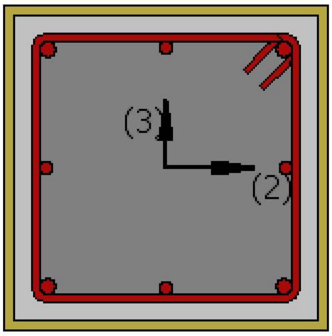
Analysis: Uniform +X

Check: Shear capacity 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 = 0.95
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary 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 = 444.4444
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -1.3563E+007
Shear Force, Va = -4519.381
EDGE -B-
Bending Moment, Mb = 0.1333213
Shear Force, Vb = 4519.381
BOTH EDGES
Axial Force, F = -5925.123
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 384262.188
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 404486.513
VCol = 404486.513
knl = 1.00
displacement_ductility_demand = 0.04959002

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 = 1.3563E+007
Vu = 4519.381

d = 0.8*h = 320.00
Nu = 5925.123
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 201061.93
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 340123.561
bw = 400.00

----

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 = 0.0002841
θy = (My*Ls/3)/EIeff = 0.00572891 ((4.29),Biskinis Phd))
My = 7.7038E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.112
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5925.123
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497530E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100837
A = 0.01459862
B = 0.00825179
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.123
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620192E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00

fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.27898785
A = 0.0143201
B = 0.00808514
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

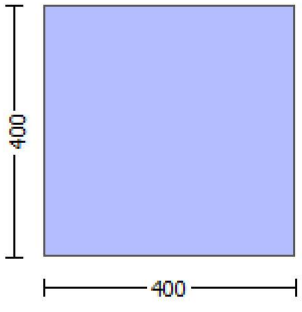
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

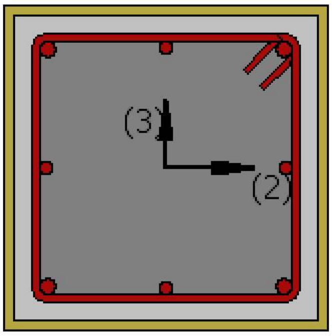
Analysis: Uniform +X

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -6.9434686E-031
EDGE -B-
Shear Force, Vb = 6.9434686E-031
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with

Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699

Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734

λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00

psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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.
$\varepsilon y1$,$\varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814

ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00

Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 4.2515079E-047
EDGE -B-
Shear Force, Vb = -4.2515079E-047
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246

with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----

psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468

εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00

Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00

$\omega_1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478$
$\omega_2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478$
$\omega_v = Asl,mid/(b*d)*(fsv/fc) = 0.04381808$
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
$\omega_1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777$
$\omega_2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777$
$\omega_v = Asl,mid/(b*d)*(fsv/fc) = 0.0562801$
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967

εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444

s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
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 Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 5.8739332E-010
Shear Force, V2 = -4519.381
Shear Force, V3 = -1.5368441E-013
Axial Force, F = -5925.123
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
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 = 0.00272023
θu = θy + θp = 0.0028634

 - Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0028634 ((4.29),Biskinis Phd))
My = 7.7038E+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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5925.123
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497530E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100837
A = 0.01459862
B = 0.00825179
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.123
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620192E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.27898785
A = 0.0143201
B = 0.00808514
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 = 0.14050197
d = 357.00
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 = 400.00
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 = 5925.123
Ag = 160000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
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

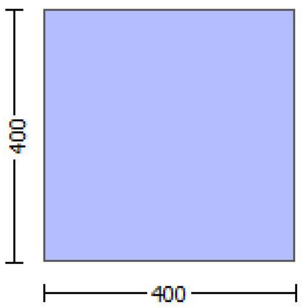
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

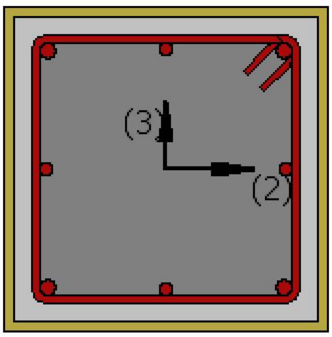
Analysis: Uniform +X

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 = 0.95
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00

Existing material of Primary 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 = 444.4444
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 5.8739332E-010
Shear Force, Va = -1.5368441E-013
EDGE -B-
Bending Moment, Mb = -1.2603819E-010
Shear Force, Vb = 1.5368441E-013
BOTH EDGES
Axial Force, F = -5925.123
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 445406.993
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.466
VCol = 468849.466
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 = 5.8739332E-010
Vu = 1.5368441E-013
d = 0.8*h = 320.00
Nu = 5925.123
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 201061.93
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 340123.561
bw = 400.00

----
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 = 1.7026306E-020
θy = (My*Ls/3)/EIeff = 0.0028634 ((4.29),Biskinis Phd))
My = 7.7038E+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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5925.123
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497530E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100837
A = 0.01459862
B = 0.00825179
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.123
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620192E-005

with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.27898785
A = 0.0143201
B = 0.00808514
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

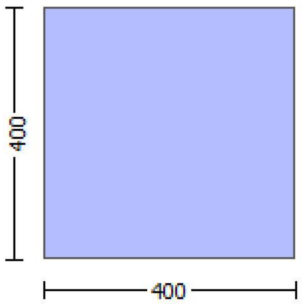
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

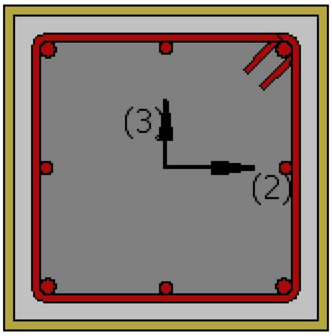
Analysis: Uniform +X

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -6.9434686E-031
EDGE -B-
Shear Force, Vb = 6.9434686E-031
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00

----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00

fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00

ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087

with $E_{sv} = E_s = 200000.00$
$\omega 1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478$
$\omega 2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478$
$\omega v = Asl,mid/(b*d)*(fsv/fc) = 0.04381808$
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
$\omega 1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777$
$\omega 2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777$
$\omega v = Asl,mid/(b*d)*(fsv/fc) = 0.0562801$
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00

εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633

fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 4.2515079E-047
EDGE -B-
Shear Force, Vb = -4.2515079E-047
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197

Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00

bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00

d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288

bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00

effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00

effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087

with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144

Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
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 Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -1.3563E+007
Shear Force, V2 = -4519.381
Shear Force, V3 = -1.5368441E-013
Axial Force, F = -5925.123
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
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 = 0.00544247
θu = θy + θp = 0.00572891

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00572891 ((4.29),Biskinis Phd))

My = 7.7038E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.112
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5925.123
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497530E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100837
A = 0.01459862
B = 0.00825179
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.123
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620192E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.27898785
A = 0.0143201
B = 0.00808514
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 = 0.14050197
d = 357.00
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 = 400.00

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 = 5925.123
Ag = 160000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
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

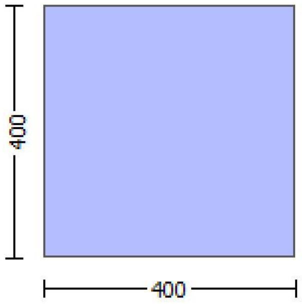
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

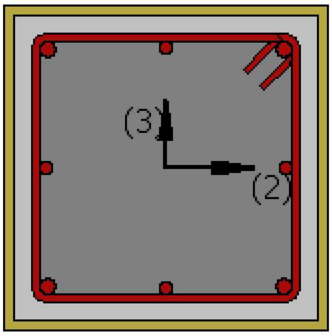
Analysis: Uniform +X

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 = 0.95
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary 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 = 444.4444
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -1.3563E+007
Shear Force, Va = -4519.381
EDGE -B-
Bending Moment, Mb = 0.1333213
Shear Force, Vb = 4519.381
BOTH EDGES
Axial Force, F = -5925.123
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 445406.993
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.466
VCol = 468849.466
knl = 1.00
displacement_ductility_demand = 0.26406097

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 = 0.1333213
Vu = 4519.381
d = 0.8*h = 320.00
Nu = 5925.123
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 201061.93
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 340123.561
bw = 400.00

----
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 = 0.00015122
θy = (My*Ls/3)/EIeff = 0.00057268 ((4.29),Biskinis Phd))
My = 7.7038E+007
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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5925.123
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497530E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100837
A = 0.01459862
B = 0.00825179
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.123
b = 400.00

δ'' = 0.12044818
Φy_comp = 1.8620192E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.27898785
A = 0.0143201
B = 0.00808514
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

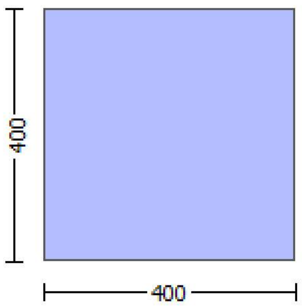
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

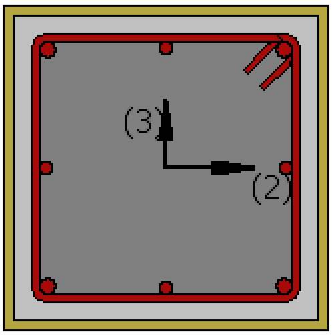
Analysis: Uniform +X

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -6.9434686E-031
EDGE -B-
Shear Force, Vb = 6.9434686E-031
BOTH EDGES
Axial Force, F = -5926.932

Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333

b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504

fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333

b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504

fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 4.2515079E-047
EDGE -B-
Shear Force, Vb = -4.2515079E-047
BOTH EDGES

Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814

ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814

ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
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 Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -1.2603819E-010
Shear Force, V2 = 4519.381
Shear Force, V3 = 1.5368441E-013
Axial Force, F = -5925.123
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805

-Middle: Asl,mid = 402.1239
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 = 0.00272023
θu = θy + θp = 0.0028634

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0028634 ((4.29),Biskinis Phd))
My = 7.7038E+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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5925.123
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497530E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100837
A = 0.01459862
B = 0.00825179
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.123
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620192E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.27898785
A = 0.0143201
B = 0.00808514
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 = 0.14050197
  d = 357.00
  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 = 400.00
  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 = 5925.123
    Ag = 160000.00
    f'cE = 20.00
    fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
  b = 400.00
  d = 357.00
    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

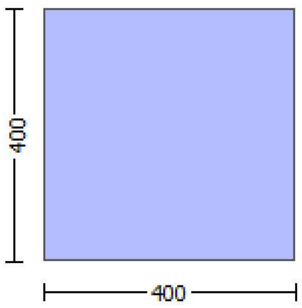
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

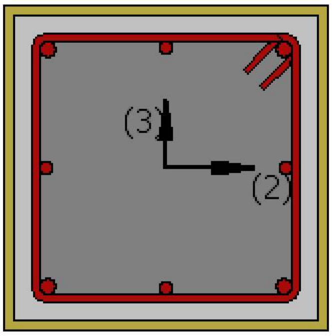
Analysis: Uniform +X

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 = 0.95
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary 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 = 444.4444
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 5.8739332E-010
Shear Force, Va = -1.5368441E-013
EDGE -B-
Bending Moment, Mb = -1.2603819E-010

Shear Force, Vb = 1.5368441E-013
BOTH EDGES
Axial Force, F = -5925.123
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 445406.993
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.466
VCol = 468849.466
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 = 1.2603819E-010
Vu = 1.5368441E-013
d = 0.8*h = 320.00
Nu = 5925.123
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 201061.93
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 340123.561
bw = 400.00

----
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 = 9.0140030E-021
θy = (My*Ls/3)/EIeff = 0.0028634 ((4.29),Biskinis Phd))
My = 7.7038E+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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5925.123
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497530E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100837
A = 0.01459862
B = 0.00825179
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.123
b = 400.00
δ" = 0.12044818
Φy_comp = 1.8620192E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.27898785
A = 0.0143201
B = 0.00808514
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

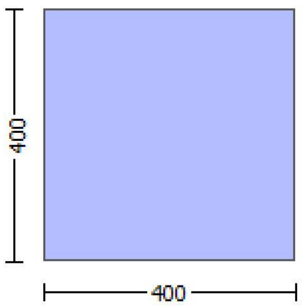
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

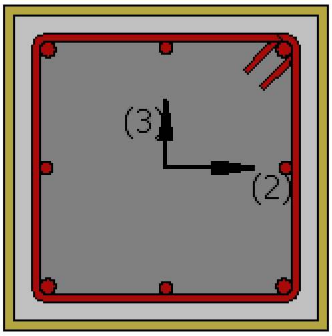
Analysis: Uniform +X

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -6.9434686E-031
EDGE -B-
Shear Force, Vb = 6.9434686E-031
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935

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

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00

v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00392699

ρsh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00

ρsh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087

with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005

Mu = 1.1045E+008

----

with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.00207526

N = 5926.932

fc = 20.00

εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.018

ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935

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

ωfx = 0.11712639

af = 0.57333333

b = 400.00

h = 400.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508

bw = 400.00

effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639

af = 0.57333333

b = 400.00

h = 400.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508

bw = 400.00

effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288

bo = 340.00

ho = 340.00

Σbi2 = 462400.00

psh,min = Min(psh,x , psh,y) = 0.00392699

----

psh,x (5.4d) = 0.00392699

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 400.00

----

psh,y (5.4d) = 0.00392699

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 400.00

----

s = 100.00

fywe = 555.5556

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00411734

λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 4.2515079E-047
EDGE -B-
Shear Force, Vb = -4.2515079E-047
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018

ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00

d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005

Mu = 1.1045E+008

----

with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.00207526

N = 5926.932

fc = 20.00

εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.018

ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935

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

ωfx = 0.11712639

af = 0.57333333

b = 400.00

h = 400.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508

bw = 400.00

effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639

af = 0.57333333

b = 400.00

h = 400.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508

bw = 400.00

effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288

bo = 340.00

ho = 340.00

Σbi2 = 462400.00

psh,min = Min(psh,x , psh,y) = 0.00392699

----

psh,x (5.4d) = 0.00392699

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 400.00

----

psh,y (5.4d) = 0.00392699

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 400.00

----

s = 100.00

fywe = 555.5556

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->

v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
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 Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00

Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 0.1333213
Shear Force, V2 = 4519.381
Shear Force, V3 = 1.5368441E-013
Axial Force, F = -5925.123
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
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 = 0.00054405
θu = θy + θp = 0.00057268

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00057268 ((4.29),Biskinis Phd))
My = 7.7038E+007
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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5925.123
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497530E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100837
A = 0.01459862
B = 0.00825179
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.123
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620192E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00

Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.27898785
A = 0.0143201
B = 0.00808514
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 = 0.14050197
d = 357.00
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 = 400.00
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 = 5925.123
Ag = 160000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
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

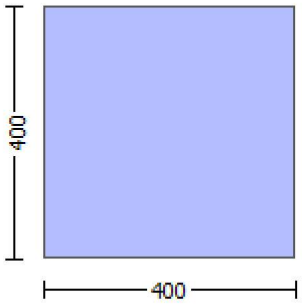
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

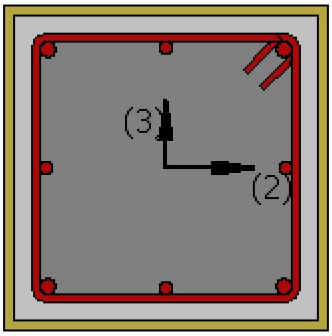
Analysis: Uniform +X

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 = 0.95
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary 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 = 444.4444
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -1.6965E+007
Shear Force, Va = -5652.966
EDGE -B-
Bending Moment, Mb = 0.16676193
Shear Force, Vb = 5652.966
BOTH EDGES
Axial Force, F = -5924.669
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 384262.145
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 404486.468
VCol = 404486.468
knl = 1.00
displacement_ductility_demand = 0.06202861

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 = 1.6965E+007
Vu = 5652.966
d = 0.8*h = 320.00
Nu = 5924.669
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 201061.93
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 340123.561

bw = 400.00

----
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 = 0.00035536
θy = (My*Ls/3)/Eleff = 0.00572891 ((4.29),Biskinis Phd))
My = 7.7038E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.112
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5924.669
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497516E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100816
A = 0.01459861
B = 0.00825178
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.669
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620196E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.2789878
A = 0.01432011
B = 0.00808514
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

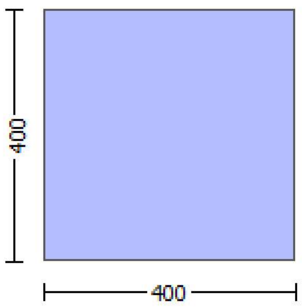
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

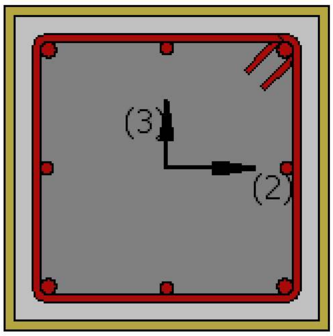
Analysis: Uniform +X

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member

Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -6.9434686E-031
EDGE -B-
Shear Force, Vb = 6.9434686E-031
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526

N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699

----

psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00

----

psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00

----

s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00

εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173

εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->

ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982

No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00

Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 4.2515079E-047
EDGE -B-
Shear Force, Vb = -4.2515079E-047
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00

v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087

with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734

λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699

Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734

λc = confinement factor = 1.21173
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339

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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
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 Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 7.3941089E-010
Shear Force, V2 = -5652.966
Shear Force, V3 = -1.9223267E-013
Axial Force, F = -5924.669
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
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 = 0.04262022
θu = θy + θp = 0.04486339

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00286339 ((4.29),Biskinis Phd))
My = 7.7038E+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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5924.669
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497516E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100816
A = 0.01459861
B = 0.00825178
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.669
b = 400.00

δ" = 0.12044818
Φy_comp = 1.8620196E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.2789878
A = 0.01432011
B = 0.00808514
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 = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.14050197
d = 357.00
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 = 400.00
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 = 5924.669
Ag = 160000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
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

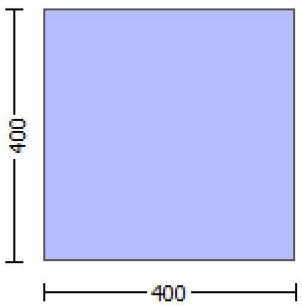
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

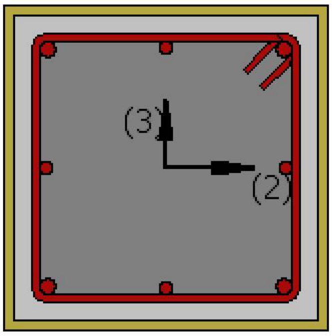
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 0.95
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary 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 = 444.4444
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 7.3941089E-010
Shear Force, Va = -1.9223267E-013
EDGE -B-
Bending Moment, Mb = -1.6233527E-010
Shear Force, Vb = 1.9223267E-013
BOTH EDGES
Axial Force, F = -5924.669
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 445406.907
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.376
VCol = 468849.376
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 = 7.3941089E-010
Vu = 1.9223267E-013
d = 0.8*h = 320.00
Nu = 5924.669
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 201061.93
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 340123.561
bw = 400.00

----
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 = 2.1296969E-020
θy = (My*Ls/3)/Eleff = 0.00286339 ((4.29),Biskinis Phd))
My = 7.7038E+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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5924.669
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497516E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100816
A = 0.01459861
B = 0.00825178
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.669
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620196E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.2789878
A = 0.01432011
B = 0.00808514
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

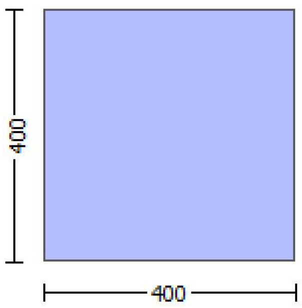
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

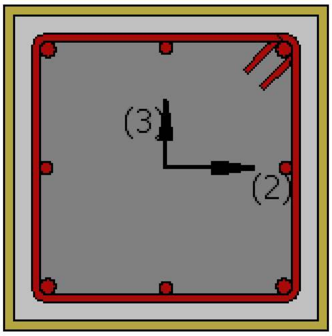
Analysis: Uniform +X

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556

##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -6.9434686E-031
EDGE -B-
Shear Force, Vb = 6.9434686E-031
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005

Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967

εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744

Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00

bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----

psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808

and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701

bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 4.2515079E-047
EDGE -B-
Shear Force, Vb = -4.2515079E-047
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008

---

with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699

---

psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00

---

psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00

---

s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173

εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->

ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982

No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699

----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
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 Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 400.00

Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -1.6965E+007
Shear Force, V2 = -5652.966
Shear Force, V3 = -1.9223267E-013
Axial Force, F = -5924.669
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
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 = 0.04534246
θu = θy + θp = 0.04772891

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00572891 ((4.29),Biskinis Phd))
My = 7.7038E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.112
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5924.669
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497516E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100816

A = 0.01459861
B = 0.00825178
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.669
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620196E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.2789878
A = 0.01432011
B = 0.00808514
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 = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.14050197
d = 357.00
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 = 400.00
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 = 5924.669
Ag = 160000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
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

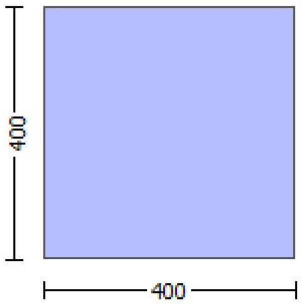
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

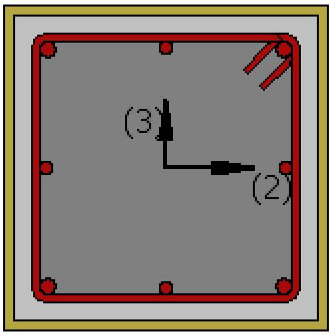
Analysis: Uniform +X

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 = 0.95
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary 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 = 444.4444
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -1.6965E+007
Shear Force, Va = -5652.966
EDGE -B-
Bending Moment, Mb = 0.16676193
Shear Force, Vb = 5652.966
BOTH EDGES
Axial Force, F = -5924.669
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 445406.907
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.376
VCol = 468849.376
knl = 1.00
displacement_ductility_demand = 0.33029499

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 = 0.16676193
Vu = 5652.966
d = 0.8*h = 320.00
Nu = 5924.669
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 201061.93
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 340123.561
bw = 400.00

----
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 = 0.00018915
θy = (My*Ls/3)/EIeff = 0.00057268 ((4.29),Biskinis Phd))
My = 7.7038E+007
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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5924.669
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497516E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100816
A = 0.01459861
B = 0.00825178
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.669
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620196E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.2789878
A = 0.01432011
B = 0.00808514

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

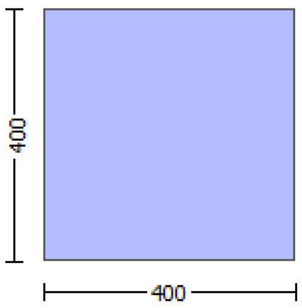
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

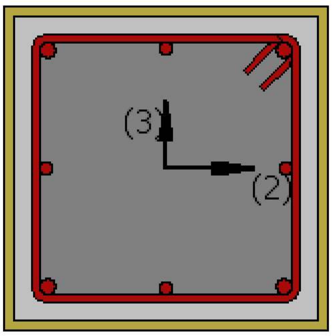
Analysis: Uniform +X

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -6.9434686E-031
EDGE -B-
Shear Force, Vb = 6.9434686E-031
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734

λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699

Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734

λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00

psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 4.2515079E-047
EDGE -B-
Shear Force, Vb = -4.2515079E-047
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00392699

ρsh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00

ρsh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->

v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----

psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468

εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00

Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
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 Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -1.6233527E-010
Shear Force, V2 = 5652.966
Shear Force, V3 = 1.9223267E-013
Axial Force, F = -5924.669
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
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 = 0.04262022
θu = θy + θp = 0.04486339

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00286339 ((4.29),Biskinis Phd))
My = 7.7038E+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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5924.669
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497516E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669

d = 357.00
ξy = 0.28100816
A = 0.01459861
B = 0.00825178
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.669
b = 400.00
δ" = 0.12044818
Φy_comp = 1.8620196E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.2789878
A = 0.01432011
B = 0.00808514
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 = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.14050197
d = 357.00
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 = 400.00
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 = 5924.669
Ag = 160000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
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

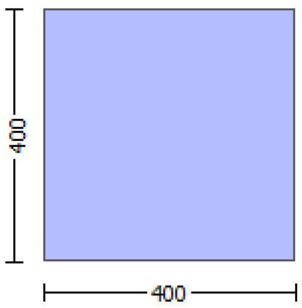
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

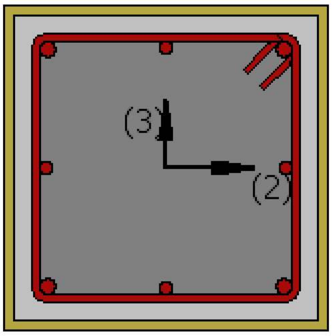
Analysis: Uniform +X

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 = 0.95
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary 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 = 444.4444
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars

Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 7.3941089E-010
Shear Force, Va = -1.9223267E-013
EDGE -B-
Bending Moment, Mb = -1.6233527E-010
Shear Force, Vb = 1.9223267E-013
BOTH EDGES
Axial Force, F = -5924.669
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 445406.907
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.376
VCol = 468849.376
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 = 1.6233527E-010
Vu = 1.9223267E-013
d = 0.8*h = 320.00
Nu = 5924.669
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 201061.93
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 340123.561
bw = 400.00

----
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 = 1.1274962E-020
θy = (My*Ls/3)/Eleff = 0.00286339 ((4.29),Biskinis Phd))
My = 7.7038E+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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5924.669
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.8497516E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100816
A = 0.01459861
B = 0.00825178
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.669
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.8620196E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.2789878

A = 0.01432011
B = 0.00808514
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

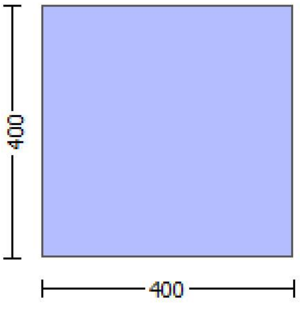
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

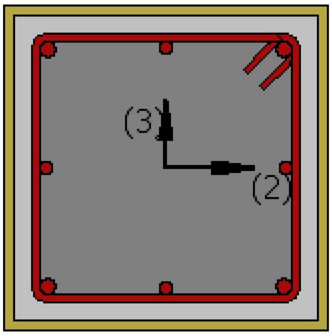
Analysis: Uniform +X

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = -6.9434686E-031
EDGE -B-
Shear Force, Vb = 6.9434686E-031
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556

fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00

----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00

fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00

ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087

with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 1.8671199E-011
Vu = 6.9434686E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
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 = 555.5556
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.21173
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
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 = 4.2515079E-047
EDGE -B-
Shear Force, Vb = -4.2515079E-047
BOTH EDGES
Axial Force, F = -5926.932
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.14050197
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 73630.246
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.1045E+008
Mu1+ = 1.1045E+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- = 1.1045E+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-) = 1.1045E+008
Mu2+ = 1.1045E+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- = 1.1045E+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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087

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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00

fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture

δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288
bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00

bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00

d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-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 = 1.7976030E-005
Mu = 1.1045E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00207526
N = 5926.932
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.14357935
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

ωfy = 0.11712639
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 804.2922

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) = 0.24250288

bo = 340.00
ho = 340.00
Σbi2 = 462400.00
psh,min = Min(psh,x , psh,y) = 0.00392699
----
psh,x (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
psh,y (5.4d) = 0.00392699
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 400.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00411734
λc = confinement factor = 1.21173
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
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 = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
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 = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
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 = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09037478
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09037478
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04381808
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 24.23468
εcc (5A.5, TBDY) = 0.00411734
λc = confinement factor = 1.21173
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1160777
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1160777
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.0562801
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2021744
Mu = MRc (4.14) = 1.1045E+008
φu = φsu (4.1) = 1.7976030E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 524051.339

Calculation of Shear Strength at edge 1, Vr1 = 524051.339
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00

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 <= 380269.701
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 524051.339
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 524051.339
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 = 4.6307395E-012
Vu = 4.2515079E-047
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 223402.144
Av = 157079.633
fy = 444.4444
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 380269.701
bw = 400.00

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 = 0.95
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 Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 0.16676193
Shear Force, V2 = 5652.966
Shear Force, V3 = 1.9223267E-013
Axial Force, F = -5924.669
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
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 = 0.04044404
θu = θy + θp = 0.04257268

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00057268 ((4.29),Biskinis Phd))
My = 7.7038E+007
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 = 1.3452E+013
factor = 0.30
Ag = 160000.00
fc' = 20.00
N = 5924.669
Ec*Ig = 4.4841E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

Φy_ten = 4.8497516E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 357.00
ξy = 0.28100816
A = 0.01459861
B = 0.00825178
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.669
b = 400.00
δ" = 0.12044818
Φy_comp = 1.8620196E-005
with fc* (12.3, (ACI 440)) = 21.65599
fc = 20.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56708553
ρg = pt + pc + pv = 0.01443197
rc = 40.00
Ae/Ac = 0.56708553
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 = 0.2789878
A = 0.01432011
B = 0.00808514
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 = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.14050197
d = 357.00
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 = 400.00
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 = 5924.669
Ag = 160000.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
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)