Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

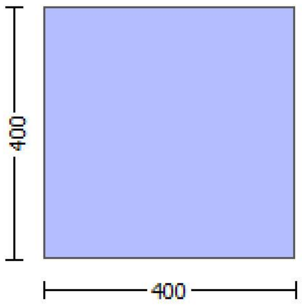
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

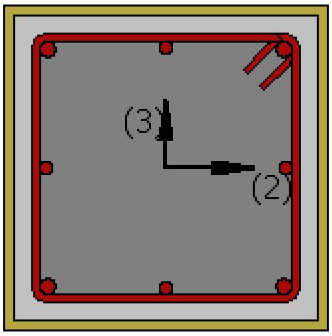
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204

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 = 24.00
Existing material: Steel Strength, fs = fsm = 525.00
##
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -1.7716E+007
Shear Force, Va = -5903.171
EDGE -B-
Bending Moment, Mb = 0.12521595
Shear Force, Vb = 5903.171
BOTH EDGES
Axial Force, F = -5924.57
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 = 404486.458
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 404486.458
VCol = 404486.458
knl = 1.00
displacement_ductility_demand = 0.03095827

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 = 1.7716E+007
Vu = 5903.171

d = 0.8*h = 320.00
Nu = 5924.57
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 211115.026
Av = 157079.633
fy = 420.00
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 = 0.00034075
θy = (My*Ls/3)/EIeff = 0.01100663 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.021
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013
factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5924.57
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087610E-005
with fy = 525.00
d = 357.00
ξy = 0.27109181
A = 0.01451099
B = 0.00816416
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.57
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773770E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00

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 = 23025.204
ξy = 0.27044207
A = 0.01432854
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 2

column C1, Floor 1

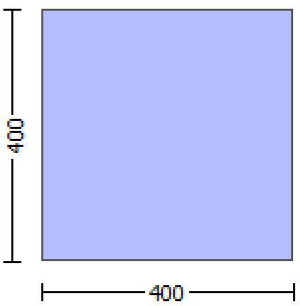
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

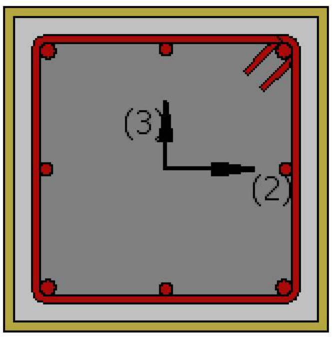
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = -4.9303520E-031
EDGE -B-
Shear Force, Vb = 4.9303520E-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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008

Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50

fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = 3.0092655E-035
EDGE -B-
Shear Force, Vb = -3.0092655E-035
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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008
Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597

λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

R = 40.00

Effective FRP thickness, $t_f = NL*t*Cos(b1) = 1.016$
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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587

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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008

ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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
Adequate Lap Length (lb/ld>=1)
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 = 1.1436911E-009
Shear Force, V2 = -5903.171
Shear Force, V3 = -3.9593309E-013
Axial Force, F = -5924.57
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 = 0.01050144
θu = θy + θp = 0.01050144

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00550144 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013

factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5924.57
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087610E-005
with fy = 525.00
d = 357.00
ξy = 0.27109181
A = 0.01451099
B = 0.00816416
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.57
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773770E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00
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 = 23025.204
ξy = 0.27044207
A = 0.01432854
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.005
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.29254855
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 = 5924.57

Ag = 160000.00
f'cE = 24.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
f'cE = 24.00

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

Calculation No. 3

column C1, Floor 1

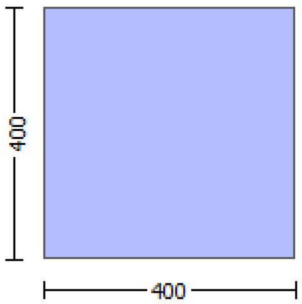
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

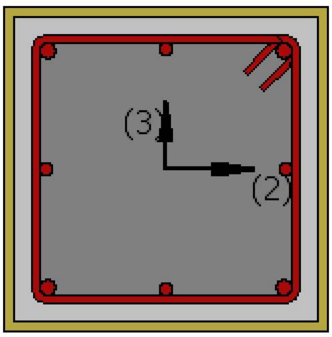
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204

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 = 24.00
Existing material: Steel Strength, fs = fsm = 525.00
##
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = 1.1436911E-009
Shear Force, Va = -3.9593309E-013
EDGE -B-
Bending Moment, Mb = 4.4442623E-011
Shear Force, Vb = 3.9593309E-013
BOTH EDGES
Axial Force, F = -5924.57
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 = 468849.356
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.356
VCol = 468849.356
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 = 1.1436911E-009
Vu = 3.9593309E-013

d = 0.8*h = 320.00
Nu = 5924.57
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 211115.026
Av = 157079.633
fy = 420.00
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 = 1.8917643E-020
θy = (My*Ls/3)/EIeff = 0.00550144 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013
factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5924.57
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087610E-005
with fy = 525.00
d = 357.00
ξy = 0.27109181
A = 0.01451099
B = 0.00816416
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.57
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773770E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00

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 = 23025.204
ξy = 0.27044207
A = 0.01432854
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 4

column C1, Floor 1

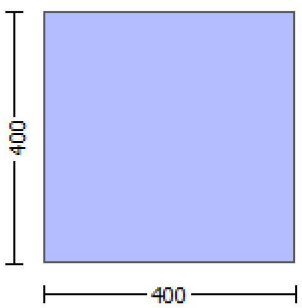
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

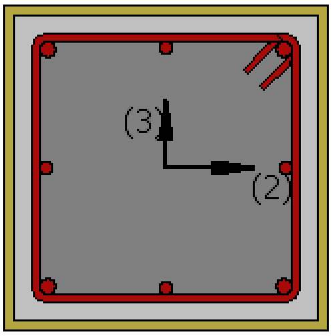
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = -4.9303520E-031
EDGE -B-
Shear Force, Vb = 4.9303520E-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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008

Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50

fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = 3.0092655E-035
EDGE -B-
Shear Force, Vb = -3.0092655E-035
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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008
Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597

λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587

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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008

ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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
Adequate Lap Length (lb/ld>=1)
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 = -1.7716E+007
Shear Force, V2 = -5903.171
Shear Force, V3 = -3.9593309E-013
Axial Force, F = -5924.57
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 = 0.01600663
θu = θy + θp = 0.01600663

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01100663 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.021
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013

factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5924.57
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087610E-005
with fy = 525.00
d = 357.00
ξy = 0.27109181
A = 0.01451099
B = 0.00816416
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.57
b = 400.00
δ" = 0.12044818
Φy_comp = 2.0773770E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00
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 = 23025.204
ξy = 0.27044207
A = 0.01432854
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.005
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.29254855
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 = 5924.57

Ag = 160000.00
f'cE = 24.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
f'cE = 24.00

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

Calculation No. 5

column C1, Floor 1

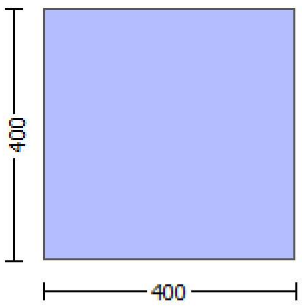
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

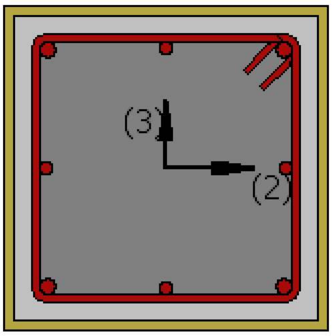
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204

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 = 24.00
Existing material: Steel Strength, fs = fsm = 525.00
##
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -1.7716E+007
Shear Force, Va = -5903.171
EDGE -B-
Bending Moment, Mb = 0.12521595
Shear Force, Vb = 5903.171
BOTH EDGES
Axial Force, F = -5924.57
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 = 468849.356
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.356
VCol = 468849.356
knl = 1.00
displacement_ductility_demand = 0.16387463

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 = 0.12521595
Vu = 5903.171

d = 0.8*h = 320.00
Nu = 5924.57
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 211115.026
Av = 157079.633
fy = 420.00
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 = 0.00018031
θy = (My*Ls/3)/EIeff = 0.00110029 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013
factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5924.57
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087610E-005
with fy = 525.00
d = 357.00
ξy = 0.27109181
A = 0.01451099
B = 0.00816416
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.57
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773770E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00

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 = 23025.204
ξy = 0.27044207
A = 0.01432854
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 6

column C1, Floor 1

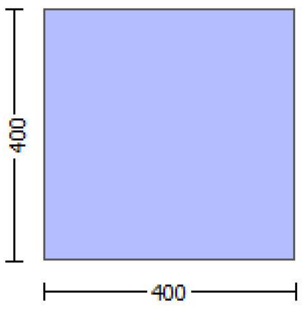
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

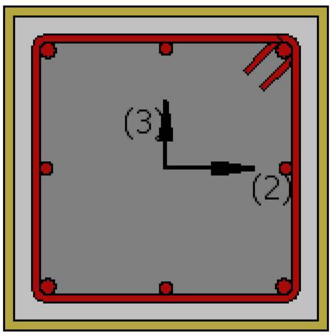
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = -4.9303520E-031
EDGE -B-
Shear Force, Vb = 4.9303520E-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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008

Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50

fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = 3.0092655E-035
EDGE -B-
Shear Force, Vb = -3.0092655E-035
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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008
Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597

λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213

```
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
   b = 340.00
   d = 327.00
   d' = 13.00
   fcc (5A.2, TBDY) = 28.28634
   εcc (5A.5, TBDY) = 0.00378597
      λc  = confinement factor = 1.1786
   ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
---------------------------------------------------------------------------
with full section properties:
   b = 400.00
   d = 357.00
   d' = 43.00
   v = 0.00172938
      N = 5926.932
   fc = 24.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
      The Shear_factor is considered equal to 1 (pure moment strength)
      From (5.4b), TBDY: εcu = 0.01775738
      ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
      where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
      ------------------------------------------------------------------
      ωfx = 0.10100587
         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 = 832.3135
      ------------------------------------------------------------------
      ωfy = 0.10100587
         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 = 832.3135
      ------------------------------------------------------------------
         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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587

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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008

ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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
Adequate Lap Length (lb/ld>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 4.4442623E-011
Shear Force, V2 = 5903.171
Shear Force, V3 = 3.9593309E-013
Axial Force, F = -5924.57
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 = 0.01050144
θu = θy + θp = 0.01050144

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00550144 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013

factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5924.57
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087610E-005
with fy = 525.00
d = 357.00
ξy = 0.27109181
A = 0.01451099
B = 0.00816416
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.57
b = 400.00
δ" = 0.12044818
Φy_comp = 2.0773770E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00
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 = 23025.204
ξy = 0.27044207
A = 0.01432854
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.005
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.29254855
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 = 5924.57

Ag = 160000.00
f'cE = 24.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
f'cE = 24.00

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

Calculation No. 7

column C1, Floor 1

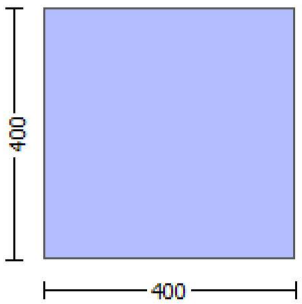
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

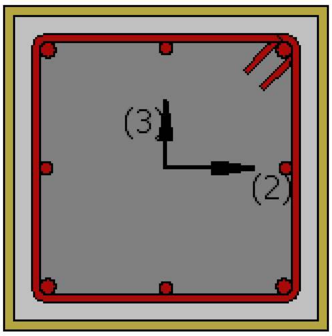
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204

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 = 24.00
Existing material: Steel Strength, fs = fsm = 525.00
##
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = 1.1436911E-009
Shear Force, Va = -3.9593309E-013
EDGE -B-
Bending Moment, Mb = 4.4442623E-011
Shear Force, Vb = 3.9593309E-013
BOTH EDGES
Axial Force, F = -5924.57
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 = 468849.356
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.356
VCol = 468849.356
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.4442623E-011
Vu = 3.9593309E-013

d = 0.8*h = 320.00
Nu = 5924.57
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 211115.026
Av = 157079.633
fy = 420.00
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 = 1.0913707E-020
θy = (My*Ls/3)/EIeff = 0.00550144 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013
factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5924.57
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087610E-005
with fy = 525.00
d = 357.00
ξy = 0.27109181
A = 0.01451099
B = 0.00816416
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.57
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773770E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00

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 = 23025.204
ξy = 0.27044207
A = 0.01432854
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 8

column C1, Floor 1

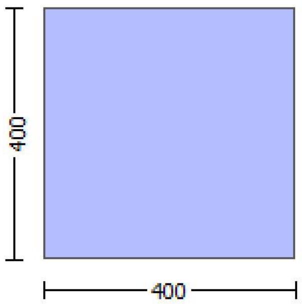
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

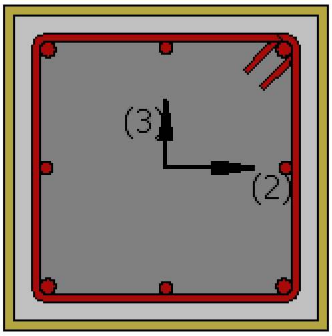
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = -4.9303520E-031
EDGE -B-
Shear Force, Vb = 4.9303520E-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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008

Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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

----
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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50

fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = 3.0092655E-035
EDGE -B-
Shear Force, Vb = -3.0092655E-035
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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008
Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597

λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587

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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008

ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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
Adequate Lap Length (lb/ld>=1)
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 = 0.12521595
Shear Force, V2 = 5903.171
Shear Force, V3 = 3.9593309E-013
Axial Force, F = -5924.57
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 = 0.00610029
θu = θy + θp = 0.00610029

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00110029 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013

factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5924.57
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087610E-005
with fy = 525.00
d = 357.00
ξy = 0.27109181
A = 0.01451099
B = 0.00816416
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5924.57
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773770E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00
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 = 23025.204
ξy = 0.27044207
A = 0.01432854
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.005
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.29254855
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 = 5924.57

Ag = 160000.00
f'cE = 24.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
f'cE = 24.00

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

Calculation No. 9

column C1, Floor 1

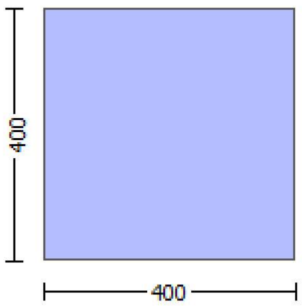
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

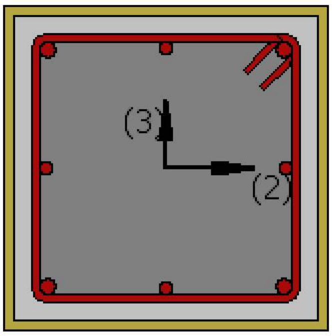
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204

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 = 24.00
Existing material: Steel Strength, fs = fsm = 525.00
##
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -1.4167E+007
Shear Force, Va = -4720.757
EDGE -B-
Bending Moment, Mb = 0.10013502
Shear Force, Vb = 4720.757
BOTH EDGES
Axial Force, F = -5925.043
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 = 404486.505
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 404486.505
VCol = 404486.505
knl = 1.00
displacement_ductility_demand = 0.02475727

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 = 1.4167E+007
Vu = 4720.757

d = 0.8*h = 320.00
Nu = 5925.043
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 211115.026
Av = 157079.633
fy = 420.00
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 = 0.00027249
θy = (My*Ls/3)/EIeff = 0.01100663 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.021
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013
factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5925.043
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087611E-005
with fy = 525.00
d = 357.00
ξy = 0.27109191
A = 0.014511
B = 0.00816417
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.043
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773766E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00

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 = 23025.204
ξy = 0.27044212
A = 0.01432853
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 10

column C1, Floor 1

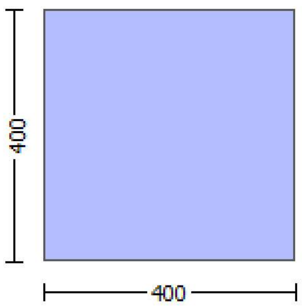
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

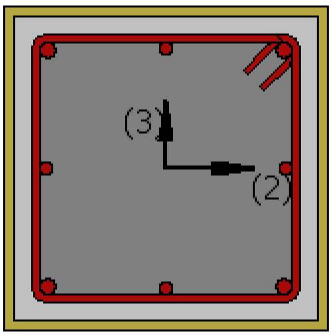
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = -4.9303520E-031
EDGE -B-
Shear Force, Vb = 4.9303520E-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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008

Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50

fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = 3.0092655E-035
EDGE -B-
Shear Force, Vb = -3.0092655E-035
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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008
Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597

λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587

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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008

ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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
Adequate Lap Length (lb/ld>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 9.1445014E-010
Shear Force, V2 = -4720.757
Shear Force, V3 = -3.1662712E-013
Axial Force, F = -5925.043
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 = 0.04296181
θu = θy + θp = 0.04296181

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00550144 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013

factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5925.043
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087611E-005
with fy = 525.00
d = 357.00
ξy = 0.27109191
A = 0.014511
B = 0.00816417
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.043
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773766E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00
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 = 23025.204
ξy = 0.27044212
A = 0.01432853
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03746037
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.29254855
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 = 5925.043

Ag = 160000.00
f'cE = 24.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
f'cE = 24.00

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

Calculation No. 11

column C1, Floor 1

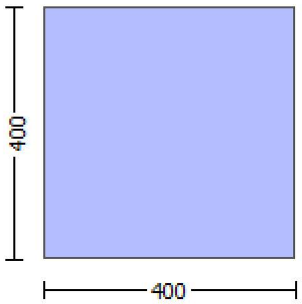
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

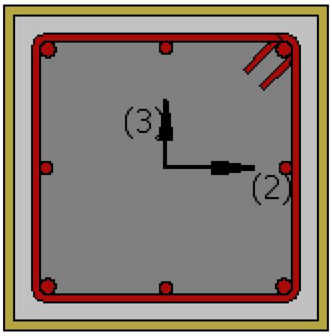
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204

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 = 24.00
Existing material: Steel Strength, fs = fsm = 525.00
##
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 9.1445014E-010
Shear Force, Va = -3.1662712E-013
EDGE -B-
Bending Moment, Mb = 3.5698647E-011
Shear Force, Vb = 3.1662712E-013
BOTH EDGES
Axial Force, F = -5925.043
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 = 468849.45
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.45
VCol = 468849.45
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 = 9.1445014E-010
Vu = 3.1662712E-013

d = 0.8*h = 320.00
Nu = 5925.043
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 211115.026
Av = 157079.633
fy = 420.00
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 = 1.5128412E-020
θy = (My*Ls/3)/EIeff = 0.00550144 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013
factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5925.043
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087611E-005
with fy = 525.00
d = 357.00
ξy = 0.27109191
A = 0.014511
B = 0.00816417
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.043
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773766E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00

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 = 23025.204
ξy = 0.27044212
A = 0.01432853
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 12

column C1, Floor 1

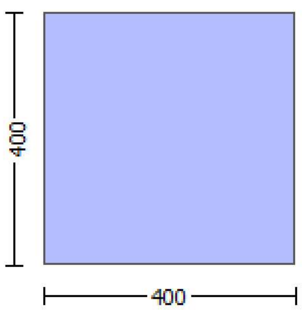
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

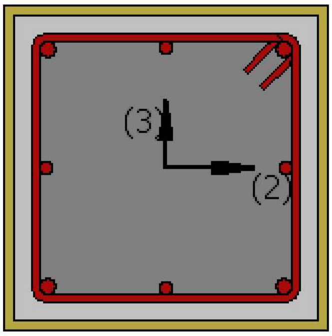
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
###
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = -4.9303520E-031
EDGE -B-
Shear Force, Vb = 4.9303520E-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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008

Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50

fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = 3.0092655E-035
EDGE -B-
Shear Force, Vb = -3.0092655E-035
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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008
Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597

λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587

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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008

ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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
Adequate Lap Length (lb/ld>=1)
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 = -1.4167E+007
Shear Force, V2 = -4720.757
Shear Force, V3 = -3.1662712E-013
Axial Force, F = -5925.043
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 = 0.048467
θu = θy + θp = 0.048467

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01100663 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.021
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013

factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5925.043
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087611E-005
with fy = 525.00
d = 357.00
ξy = 0.27109191
A = 0.014511
B = 0.00816417
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.043
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773766E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00
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 = 23025.204
ξy = 0.27044212
A = 0.01432853
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03746037
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.29254855
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 = 5925.043

Ag = 160000.00
f'cE = 24.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
f'cE = 24.00

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

Calculation No. 13

column C1, Floor 1

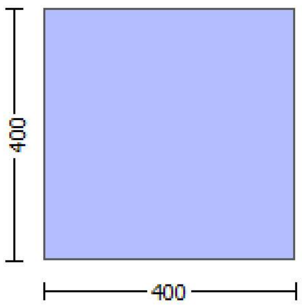
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

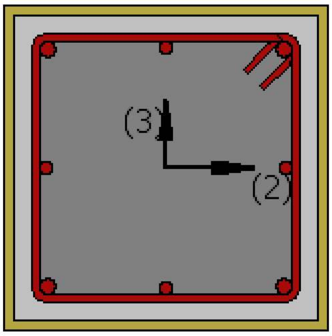
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204

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 = 24.00
Existing material: Steel Strength, fs = fsm = 525.00
##
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -1.4167E+007
Shear Force, Va = -4720.757
EDGE -B-
Bending Moment, Mb = 0.10013502
Shear Force, Vb = 4720.757
BOTH EDGES
Axial Force, F = -5925.043
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 = 468849.45
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.45
VCol = 468849.45
knl = 1.00
displacement_ductility_demand = 0.13105024

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 = 0.10013502
Vu = 4720.757

d = 0.8*h = 320.00
Nu = 5925.043
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 211115.026
Av = 157079.633
fy = 420.00
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 = 0.00014419
θy = (My*Ls/3)/Eleff = 0.00110029 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.4736E+013
factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5925.043
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087611E-005
with fy = 525.00
d = 357.00
ξy = 0.27109191
A = 0.014511
B = 0.00816417
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.043
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773766E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00

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 = 23025.204
ξy = 0.27044212
A = 0.01432853
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 14

column C1, Floor 1

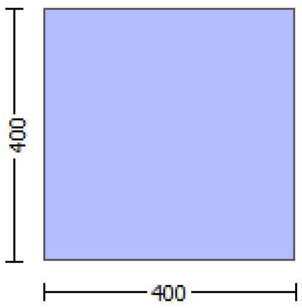
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

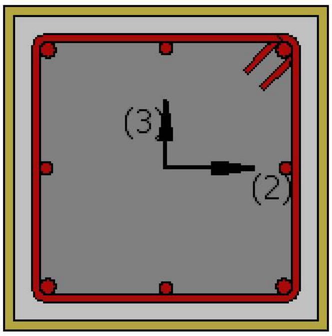
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = -4.9303520E-031
EDGE -B-
Shear Force, Vb = 4.9303520E-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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008

Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50

fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = 3.0092655E-035
EDGE -B-
Shear Force, Vb = -3.0092655E-035
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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008
Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597

λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
        with Esv = Es = 200000.00
   ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
   b = 340.00
   d = 327.00
   d' = 13.00
   fcc (5A.2, TBDY) = 28.28634
   εcc (5A.5, TBDY) = 0.00378597
      λc  = confinement factor = 1.1786
   ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2-
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
---------------------------------------------------------------------------
with full section properties:
   b = 400.00
   d = 357.00
   d' = 43.00
   v = 0.00172938
      N = 5926.932
   fc = 24.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
      The Shear_factor is considered equal to 1 (pure moment strength)
      From (5.4b), TBDY: εcu = 0.01775738
      ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
      where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)
      -------------------------------------------------------------------
      ωfx = 0.10100587
         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 = 832.3135
      -------------------------------------------------------------------
      ωfy = 0.10100587
```

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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008

ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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
Adequate Lap Length (lb/ld>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 3.5698647E-011
Shear Force, V2 = 4720.757
Shear Force, V3 = 3.1662712E-013
Axial Force, F = -5925.043
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 = 0.04296181
θu = θy + θp = 0.04296181

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00550144 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013

factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5925.043
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087611E-005
with fy = 525.00
d = 357.00
ξy = 0.27109191
A = 0.014511
B = 0.00816417
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.043
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773766E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00
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 = 23025.204
ξy = 0.27044212
A = 0.01432853
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03746037
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.29254855
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 = 5925.043

Ag = 160000.00
f'cE = 24.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
f'cE = 24.00

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

Calculation No. 15

column C1, Floor 1

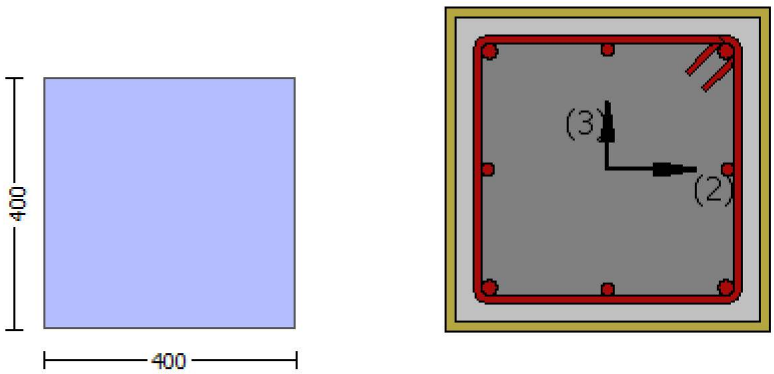
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



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

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 23025.204

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 = 24.00
Existing material: Steel Strength, fs = fsm = 525.00
##
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
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 9.1445014E-010
Shear Force, Va = -3.1662712E-013
EDGE -B-
Bending Moment, Mb = 3.5698647E-011
Shear Force, Vb = 3.1662712E-013
BOTH EDGES
Axial Force, F = -5925.043
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 = 468849.45
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 468849.45
VCol = 468849.45
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.5698647E-011
Vu = 3.1662712E-013

d = 0.8*h = 320.00
Nu = 5925.043
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 211115.026
Av = 157079.633
fy = 420.00
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 = 8.7276754E-021
θy = (My*Ls/3)/EIeff = 0.00550144 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013
factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5925.043
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087611E-005
with fy = 525.00
d = 357.00
ξy = 0.27109191
A = 0.014511
B = 0.00816417
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.043
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773766E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00

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 = 23025.204
ξy = 0.27044212
A = 0.01432853
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 16

column C1, Floor 1

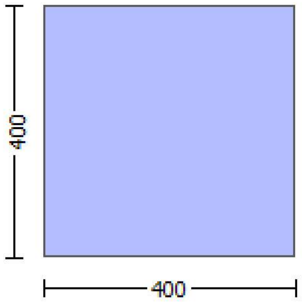
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

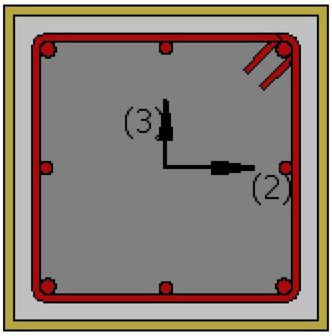
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





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

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

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = -4.9303520E-031
EDGE -B-
Shear Force, Vb = 4.9303520E-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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008

Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50

fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 7.8854372E-013
Vu = 4.9303520E-031
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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 = 656.25
##
Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.1786
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
Adequate Lap Length (lo/lou,min>=1)
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 = 3.0092655E-035
EDGE -B-
Shear Force, Vb = -3.0092655E-035
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 = 0.29254855
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 167910.353
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.5187E+008
Mu1+ = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.5187E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.5187E+008
Mu2+ = 2.5187E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.5187E+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 = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597

λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587
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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.00010752
Mu = 2.5187E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00172938
N = 5926.932
fc = 24.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01775738
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01775738
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.1270455
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.10100587
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 = 832.3135

ωfy = 0.10100587

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 = 832.3135

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 = 656.25
fce = 24.00
From ((5.A5), TBDY), TBDY: εcc = 0.00378597
λc = confinement factor = 1.1786
εy1 = 0.0025
εsh1 = 0.008
ft1 = 787.50
fy1 = 656.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 787.50
fy2 = 656.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008

ftv = 787.50
fyv = 656.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 1.00
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 = 656.25
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15881213
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15881213
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07699982
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 28.28634
εcc (5A.5, TBDY) = 0.00378597
λc = confinement factor = 1.1786
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20397888
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20397888
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09889885
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16631786
Mu = MRc (4.14) = 2.5187E+008
φu = φsu (4.1) = 0.00010752

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 573957.229

Calculation of Shear Strength at edge 1, Vr1 = 573957.229
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 573957.229
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 573957.229
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' = 24.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4041483E-016
Vu = 3.0092655E-035
d = 0.8*h = 320.00
Nu = 5926.932
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = 263893.783
Av = 157079.633
fy = 525.00
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 <= 416564.586
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 = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 24.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 23025.204
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
Adequate Lap Length (lb/ld>=1)
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 = 0.10013502
Shear Force, V2 = 4720.757
Shear Force, V3 = 3.1662712E-013
Axial Force, F = -5925.043
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 = 0.03856066
θu = θy + θp = 0.03856066

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00110029 ((4.29),Biskinis Phd))
My = 1.6214E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4736E+013

factor = 0.30
Ag = 160000.00
fc' = 24.00
N = 5925.043
Ec*Ig = 4.9120E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.0087611E-005
with fy = 525.00
d = 357.00
ξy = 0.27109191
A = 0.014511
B = 0.00816417
with pt = 0.00580799
pc = 0.00580799
pv = 0.00281599
N = 5925.043
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.0773766E-005
with fc* (12.3, (ACI 440)) = 25.65599
fc = 24.00
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 = 23025.204
ξy = 0.27044212
A = 0.01432853
B = 0.00808514
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03746037
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.29254855
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 = 5925.043

Ag = 160000.00
f'cE = 24.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01443197
b = 400.00
d = 357.00
f'cE = 24.00

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