Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

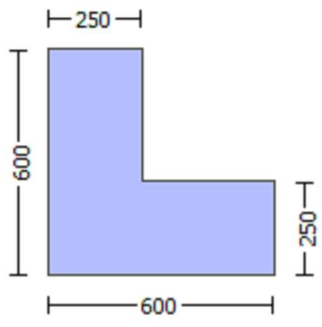
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

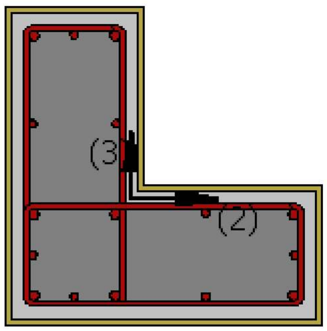
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
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 = -1.2946E+007
Shear Force, Va = -4259.045
EDGE -B-
Bending Moment, Mb = 164093.879
Shear Force, Vb = 4259.045
BOTH EDGES
Axial Force, F = -9662.362
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL,ten = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 292301.036
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 379611.735
VCol = 379611.735
knl = 1.00
displacement_ductility_demand = 0.01786943

NOTE: In expression (10-3) 'Vs' 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 = 1.2946E+007
Vu = 4259.045
d = 0.8*h = 480.00
Nu = 9662.362
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 284837.734
where:
Vs1 = 83775.804 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 201061.93 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 318865.838
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation θ = 0.00012672
θy = (My*Ls/3)/Eleff = 0.0070913 ((4.29),Biskinis Phd))
My = 2.9341E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3039.546
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9662.362
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0518245E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00

ξy = 0.3842998
A = 0.02984946
B = 0.0192317
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9662.362
b = 250.00
δ" = 0.07719928
Φy_comp = 8.1947240E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38318842
A = 0.02940142
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

End Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

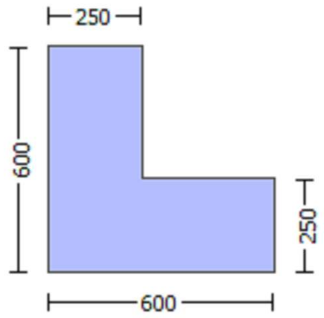
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

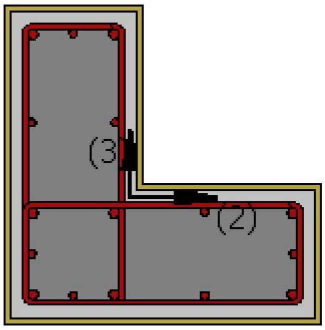
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246

with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1

db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984

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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864

fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441

fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672

Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

----

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

----

s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24078
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24081
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00

Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00

v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00321875
Expression ((5.4d), TBDY) for ρsh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738

εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied

--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205

εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00

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

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738

εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80

ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23669
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688

knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23667
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44

Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
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 = -320830.403
Shear Force, V2 = -4259.045
Shear Force, V3 = 148.2786
Axial Force, F = -9662.362
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00388691
θu = θy + θp = 0.00504794

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00504794 ((4.29),Biskinis Phd))
My = 2.9341E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2163.70
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9662.362
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0518245E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.3842998
A = 0.02984946
B = 0.0192317
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9662.362
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1947240E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38318842
A = 0.02940142
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.62612363
d = 557.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1460.00, is the total Length of all stirrups parallel to loading (shear) direction

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 = 9662.362
Ag = 237500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02959978
b = 250.00
d = 557.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

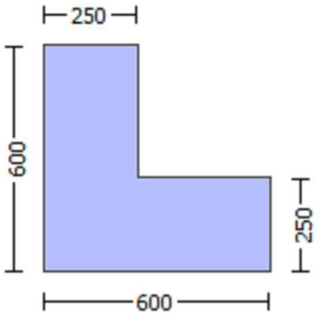
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

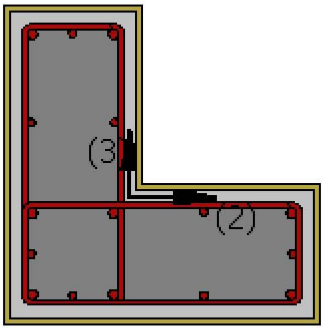
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
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 = -320830.403
Shear Force, Va = 148.2786
EDGE -B-
Bending Moment, Mb = -122390.945
Shear Force, Vb = -148.2786
BOTH EDGES
Axial Force, F = -9662.362
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL,ten = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 292301.036
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 379611.735
VCol = 379611.735
knl = 1.00
displacement_ductility_demand = 0.00940177

NOTE: In expression (10-3) 'Vs' 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 = 320830.403
Vu = 148.2786
d = 0.8*h = 480.00
Nu = 9662.362
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 284837.734
where:
Vs1 = 201061.93 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 83775.804 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 318865.838
bw = 250.00

----
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 = 4.7459577E-005
θy = (My*Ls/3)/EIeff = 0.00504794 ((4.29),Biskinis Phd))
My = 2.9341E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2163.70
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9662.362
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0518245E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.3842998
A = 0.02984946
B = 0.0192317
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9662.362
b = 250.00
δ" = 0.07719928
Φy_comp = 8.1947240E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38318842
A = 0.02940142
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

End Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

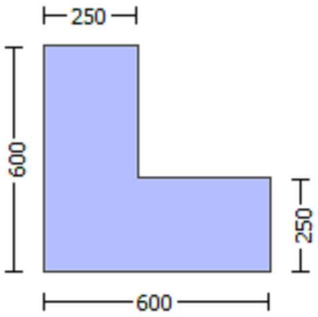
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

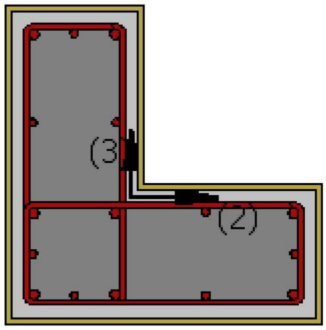
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00

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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

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

Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097

ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008

----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00

fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture

δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00

n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24078
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)

fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24081
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##

Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:

φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

----

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875

Lstir (Length of stirrups along Y) = 1460.00

Astir (stirrups area) = 78.53982

Asec (section area) = 237500.00

----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875

Lstir (Length of stirrups along X) = 1460.00

Astir (stirrups area) = 78.53982

Asec (section area) = 237500.00

----

s = 150.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00298102

λc = confinement factor = 1.0981

εy1 = 0.00124738

εsh1 = 0.00431097

ft1 = 359.2441

fy1 = 299.3701

εsu1 = 0.00446911

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.28304984

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 = 299.3701

with Es1 = Es = 200000.00

εy2 = 0.00124738

εsh2 = 0.00431097

ft2 = 359.2441

fy2 = 299.3701

εsu2 = 0.00446911

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.28304984

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 = 299.3701

with Es2 = Es = 200000.00

εyv = 0.00124738

εshv = 0.00431097

ftv = 359.2441

fyv = 299.3701

εsuv = 0.00446911

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.28304984

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 = 299.3701

with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209

$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
$\varphi u = \varphi su$ (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu^* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23669
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23667
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
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 = -1.2946E+007
Shear Force, V2 = -4259.045
Shear Force, V3 = 148.2786
Axial Force, F = -9662.362
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0054603
θu = θy + θp = 0.0070913

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0070913 ((4.29),Biskinis Phd))
My = 2.9341E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3039.546
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9662.362
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0518245E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.3842998
A = 0.02984946
B = 0.0192317
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9662.362
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1947240E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38318842
A = 0.02940142
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.62612363
d = 557.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1460.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 9662.362
Ag = 237500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02959978
b = 250.00
d = 557.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

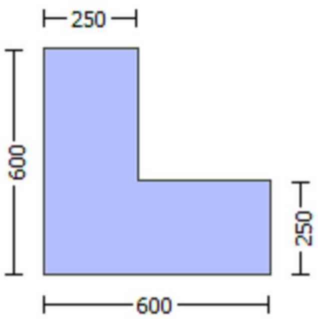
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

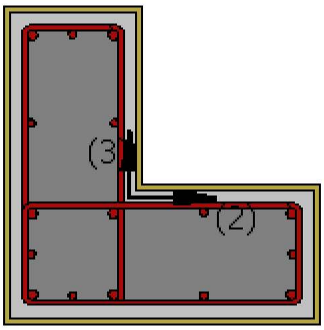
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 2

Integration Section: (b)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
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 = -1.2946E+007
Shear Force, Va = -4259.045
EDGE -B-
Bending Moment, Mb = 164093.879
Shear Force, Vb = 4259.045
BOTH EDGES
Axial Force, F = -9662.362
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL,ten = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 339075.376
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 440357.631
VCol = 440357.631
knl = 1.00
displacement_ductility_demand = 0.06818797

NOTE: In expression (10-3) 'Vs' 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 = 164093.879
Vu = 4259.045
d = 0.8*h = 480.00
Nu = 9662.362
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 284837.734
where:
Vs1 = 83775.804 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 201061.93 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 318865.838
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 4.7725017E-005
θy = (My*Ls/3)/EIeff = 0.0006999 ((4.29),Biskinis Phd))
My = 2.9341E+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 = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9662.362

Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0518245E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.3842998
A = 0.02984946
B = 0.0192317
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9662.362
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1947240E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38318842
A = 0.02940142
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

End Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

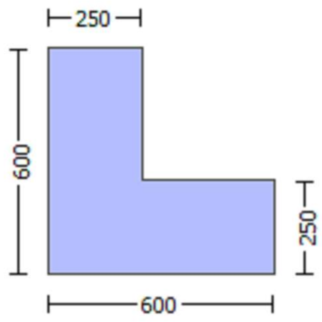
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

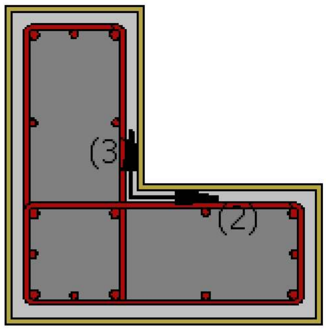
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864

fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441

fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672

Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00

Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00

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

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441

fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00

Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24078
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24081
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205

εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00

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

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738

εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80

ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008

---

with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length

equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23669
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00

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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23667
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 2

Integration Section: (b)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
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 = -122390.945
Shear Force, V2 = 4259.045
Shear Force, V3 = -148.2786
Axial Force, F = -9662.362
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00148279
θu = θy + θp = 0.0019257

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0019257 ((4.29),Biskinis Phd))
My = 2.9341E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 825.4121
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.1921E+013
factor = 0.30

Ag = 237500.00
fc' = 20.00
N = 9662.362
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0518245E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.3842998
A = 0.02984946
B = 0.0192317
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9662.362
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1947240E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38318842
A = 0.02940142
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VCol0E = 0.62612363
  d = 557.00
  s = 0.00
  ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
  Av = 78.53982, is the area of every stirrup
  Lstir = 1460.00, is the total Length of all stirrups parallel to loading (shear) direction
  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 = 9662.362
    Ag = 237500.00
    f'cE = 20.00
    fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02959978
  b = 250.00
  d = 557.00
    f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

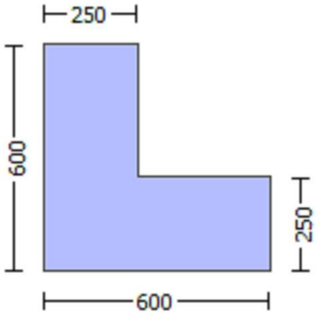
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

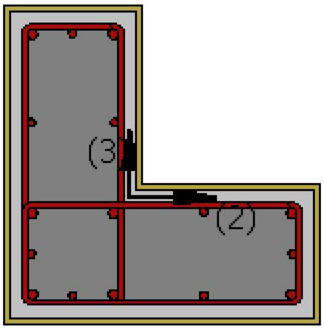
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
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 = -320830.403
Shear Force, Va = 148.2786
EDGE -B-
Bending Moment, Mb = -122390.945
Shear Force, Vb = -148.2786
BOTH EDGES
Axial Force, F = -9662.362
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL,ten = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 339075.376
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 440357.631
VCol = 440357.631
knl = 1.00
displacement_ductility_demand = 1.2067023E-005

NOTE: In expression (10-3) 'Vs' 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 = 122390.945
Vu = 148.2786
d = 0.8*h = 480.00
Nu = 9662.362
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 284837.734
where:
Vs1 = 201061.93 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 83775.804 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 318865.838
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation θ = 2.3237426E-008
θy = (My*Ls/3)/EIeff = 0.0019257 ((4.29),Biskinis Phd))
My = 2.9341E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 825.4121
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.1921E+013

factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9662.362
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0518245E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.3842998
A = 0.02984946
B = 0.0192317
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9662.362
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1947240E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38318842
A = 0.02940142
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

End Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

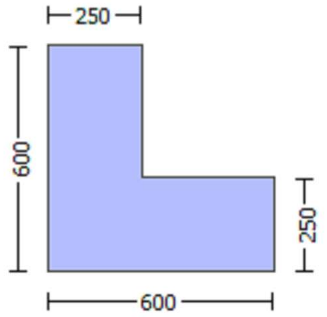
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

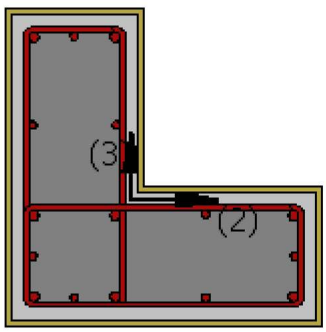
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00

d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102

λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied

--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00

hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982

Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00

d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333

bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701

with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24078
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24081
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875

Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:

b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912

N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097

ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008

φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23669
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23667
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
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 = 164093.879
Shear Force, V2 = 4259.045
Shear Force, V3 = -148.2786
Axial Force, F = -9662.362
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00053893
θu = θy + θp = 0.0006999

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0006999 ((4.29),Biskinis Phd))

My = 2.9341E+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 = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9662.362
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0518245E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.3842998
A = 0.02984946
B = 0.0192317
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9662.362
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1947240E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38318842
A = 0.02940142
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis

s = 150.00
n = 16.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.62612363
d = 557.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1460.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 9662.362
Ag = 237500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02959978
b = 250.00
d = 557.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

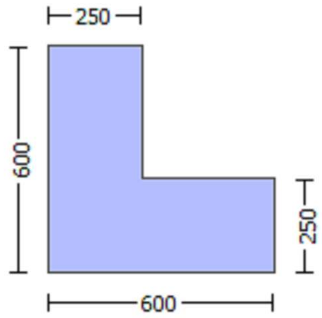
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

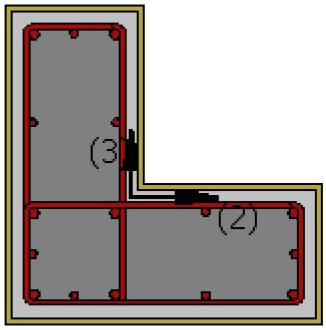
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
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 = -1.0749E+007
Shear Force, Va = -3536.316

EDGE -B-
Bending Moment, Mb = 136240.323
Shear Force, Vb = 3536.316
BOTH EDGES
Axial Force, F = -9530.256
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL,ten = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 292291.023
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 379598.731
VCol = 379598.731
knl = 1.00
displacement_ductility_demand = 0.01483887

NOTE: In expression (10-3) 'Vs' 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 = 1.0749E+007
Vu = 3536.316
d = 0.8*h = 480.00
Nu = 9530.256
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 284837.734
where:
Vs1 = 83775.804 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 201061.93 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 318865.838
bw = 250.00

---
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation θ = 0.00010522
θy = (My*Ls/3)/Eleff = 0.00709067 ((4.29),Biskinis Phd))
My = 2.9338E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3039.544
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9530.256
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0516275E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.38426988
A = 0.02984605
B = 0.01922829
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9530.256
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1950430E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38317351
A = 0.02940413
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1

db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

End Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

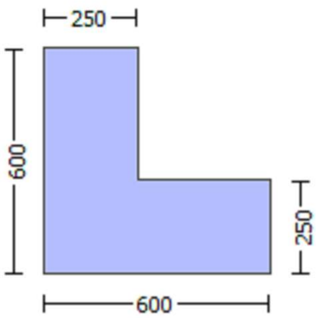
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

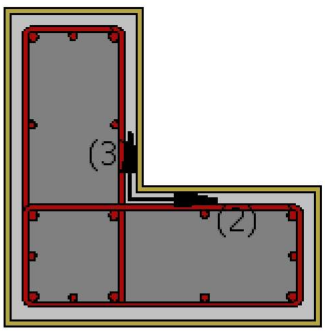
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875

Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:

b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912

N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097

ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008

φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24078
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24081
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00

d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00321875
Expression ((5.4d), TBDY) for ρsh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981

εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->

ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

----

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

----

s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00

fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23669
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:

d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23667
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
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 = -266395.829
Shear Force, V2 = -3536.316
Shear Force, V3 = 123.1168
Axial Force, F = -9530.256
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805

-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03622669
θu = θy + θp = 0.04704765

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00504765 ((4.29),Biskinis Phd))
My = 2.9338E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2163.765
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9530.256
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0516275E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.38426988
A = 0.02984605
B = 0.01922829
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9530.256
b = 250.00
δ" = 0.07719928
Φy_comp = 8.1950430E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38317351
A = 0.02940413
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00

ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.62612363
d = 557.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1460.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 9530.256
Ag = 237500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02959978
b = 250.00
d = 557.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

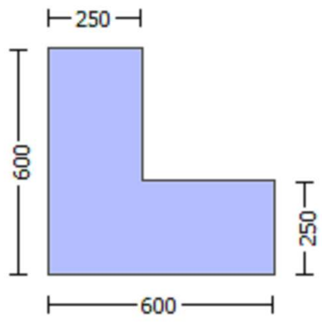
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

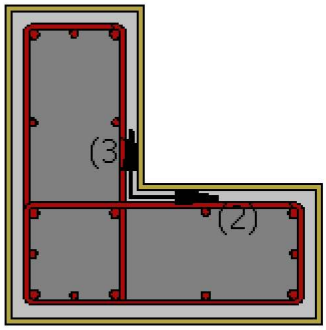
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
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 = -266395.829
Shear Force, Va = 123.1168
EDGE -B-
Bending Moment, Mb = -101614.073
Shear Force, Vb = -123.1168
BOTH EDGES
Axial Force, F = -9530.256
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL,ten = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 292291.023
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 379598.731
VCol = 379598.731
knl = 1.00
displacement_ductility_demand = 0.00780743

NOTE: In expression (10-3) 'Vs' 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 = 266395.829
Vu = 123.1168
d = 0.8*h = 480.00
Nu = 9530.256
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 284837.734
where:
Vs1 = 201061.93 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 83775.804 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 318865.838
bw = 250.00

----
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 = 3.9409129E-005
θy = (My*Ls/3)/Eleff = 0.00504765 ((4.29),Biskinis Phd))
My = 2.9338E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2163.765
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9530.256
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0516275E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.38426988
A = 0.02984605
B = 0.01922829
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9530.256
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1950430E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38317351

A = 0.02940413
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

End Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

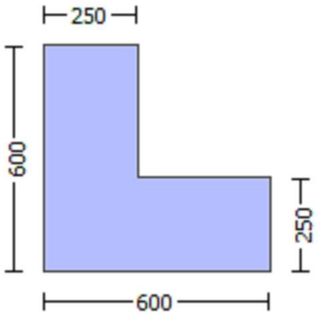
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

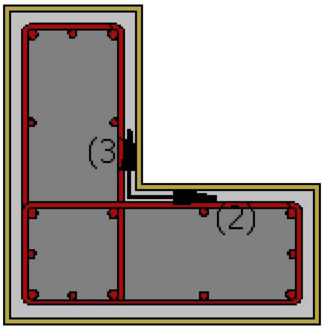
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00

d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00321875
Expression ((5.4d), TBDY) for ρsh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981

εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->

ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00

----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00

fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24078
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:

d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24081
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213

BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00

Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00

d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00

hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00

εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55

fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23669
Vu = 0.00016213

d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23667
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44

s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
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 = -1.0749E+007
Shear Force, V2 = -3536.316
Shear Force, V3 = 123.1168
Axial Force, F = -9530.256
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03779982
θu = θy + θp = 0.04909067

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00709067 ((4.29),Biskinis Phd))
My = 2.9338E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3039.544
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9530.256
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0516275E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.38426988
A = 0.02984605
B = 0.01922829
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9530.256
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1950430E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01

Ef = 64828.00
Ec = 21019.039
ξy = 0.38317351
A = 0.02940413
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.62612363
d = 557.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1460.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 9530.256
Ag = 237500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02959978
b = 250.00
d = 557.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

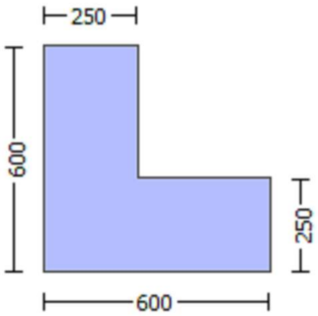
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

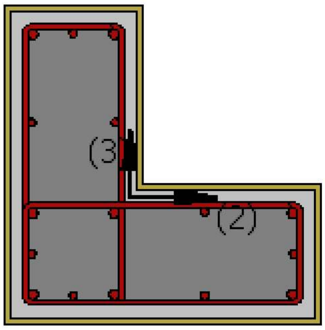
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
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 = -1.0749E+007
Shear Force, Va = -3536.316
EDGE -B-
Bending Moment, Mb = 136240.323
Shear Force, Vb = 3536.316
BOTH EDGES
Axial Force, F = -9530.256
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL,ten = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 339055.351
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 440331.624
VCol = 440331.624
knl = 1.00
displacement_ductility_demand = 0.05662636

NOTE: In expression (10-3) 'Vs' 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 = 136240.323
Vu = 3536.316
d = 0.8*h = 480.00
Nu = 9530.256
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 284837.734
where:
Vs1 = 83775.804 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 201061.93 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 400.00

s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 318865.838
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 3.9629525E-005
θy = (My*Ls/3)/EIeff = 0.00069984 ((4.29),Biskinis Phd))
My = 2.9338E+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 = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9530.256
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0516275E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.38426988
A = 0.02984605
B = 0.01922829
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9530.256
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1950430E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00

Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38317351
A = 0.02940413
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

End Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

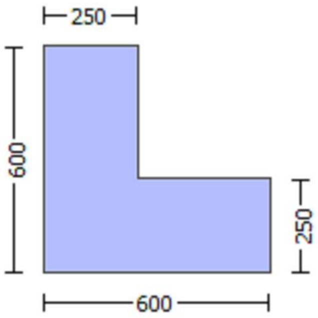
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

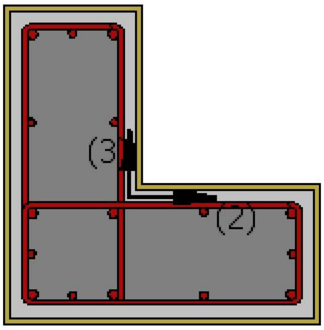
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213

BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00

Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00

d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00

hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00

εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55

fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24078
Vu = 0.00016213

d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24081
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44

s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246

with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1

db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008

---

with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984

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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864

fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441

fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672

Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23669
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23667
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length lb = 300.00
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 = -101614.073
Shear Force, V2 = 3536.316
Shear Force, V3 = -123.1168
Axial Force, F = -9530.256
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03382254
θu = θy + θp = 0.04392538

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00192538 ((4.29),Biskinis Phd))
My = 2.9338E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 825.3468
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9530.256
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0516275E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.38426988
A = 0.02984605
B = 0.01922829
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9530.256
b = 250.00
δ'' = 0.07719928

Φy_comp = 8.1950430E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38317351
A = 0.02940413
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.62612363
d = 557.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1460.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 9530.256
Ag = 237500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02959978
b = 250.00
d = 557.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1

At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

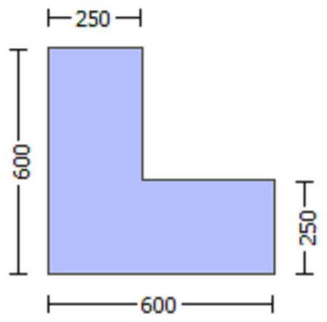
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

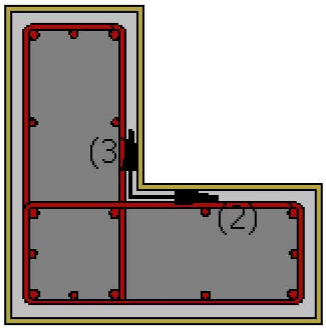
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##

Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
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 = -266395.829
Shear Force, Va = 123.1168
EDGE -B-
Bending Moment, Mb = -101614.073
Shear Force, Vb = -123.1168
BOTH EDGES
Axial Force, F = -9530.256
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL,ten = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 339055.351
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 440331.624
VCol = 440331.624
knl = 1.00
displacement_ductility_demand = 1.1629571E-005

NOTE: In expression (10-3) 'Vs' 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 = 101614.073
Vu = 123.1168
d = 0.8*h = 480.00
Nu = 9530.256
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 284837.734
where:
Vs1 = 201061.93 is calculated for section web, with:

d = 480.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 83775.804 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 318865.838
bw = 250.00

---

displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation θ = 2.2391291E-008
θy = (My*Ls/3)/Eleff = 0.00192538 ((4.29),Biskinis Phd))
My = 2.9338E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 825.3468
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9530.256
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.0516275E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.38426988
A = 0.02984605
B = 0.01922829
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9530.256
b = 250.00

δ'' = 0.07719928
Φy_comp = 8.1950430E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38317351
A = 0.02940413
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

End Of Calculation of Shear Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

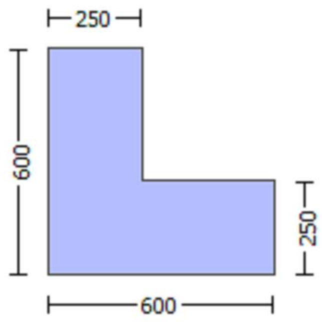
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

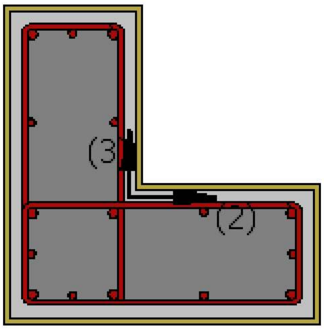
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246

with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1

db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984

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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864

fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441

fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672

Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24078
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.24081
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 223399.91 is calculated for section web, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 93083.296 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.0981
Element Length, L = 3000.00

Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
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 = 0.00016213
EDGE -B-
Shear Force, Vb = -0.00016213
BOTH EDGES
Axial Force, F = -8883.864
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664

Calculation of Shear Capacity ratio , Ve/Vr = 0.62612363
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 265620.233
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.9843E+008
Mu1+ = 3.9843E+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- = 2.1970E+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-) = 3.9843E+008
Mu2+ = 3.9843E+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- = 2.1970E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00

v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738

εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied

--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.1848408E-005
Mu = 3.9843E+008
----
with full section properties:
b = 250.00
d = 557.00
d' = 43.00
v = 0.0031899
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738
εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18776209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08915322
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16614919
and confined core properties:
b = 190.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205

εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26111925
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.12398468
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23106236
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.32281672
Mu = MRc (4.15) = 3.9843E+008
φu = φsu (4.1) = 1.1848408E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.6917274E-006
Mu = 2.1970E+008
----
with full section properties:
b = 600.00
d = 557.00
d' = 43.00
v = 0.00132912
N = 8883.864
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0144353
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0144353
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.07473805
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 57233.333
bmax = 600.00
hmax = 600.00

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

ωfy = 0.06888919
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.24098246
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 600.00
hmax = 600.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.21805635
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 169100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 98400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 105733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00321875
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along Y) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00321875
Lstir (Length of stirrups along X) = 1460.00
Astir (stirrups area) = 78.53982
Asec (section area) = 237500.00
----
s = 150.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00298102
λc = confinement factor = 1.0981
εy1 = 0.00124738
εsh1 = 0.00431097
ft1 = 359.2441
fy1 = 299.3701
εsu1 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Es1 = Es = 200000.00
εy2 = 0.00124738

εsh2 = 0.00431097
ft2 = 359.2441
fy2 = 299.3701
εsu2 = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.28304984
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 = 299.3701
with Es2 = Es = 200000.00
εyv = 0.00124738
εshv = 0.00431097
ftv = 359.2441
fyv = 299.3701
εsuv = 0.00446911
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.28304984
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 = 299.3701
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03714718
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0782342
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.06922883
and confined core properties:
b = 540.00
d = 527.00
d' = 13.00
fcc (5A.2, TBDY) = 21.96205
εcc (5A.5, TBDY) = 0.00298102
λc = confinement factor = 1.0981
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04362424
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09187529
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08129972
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17212448
Mu = MRc (4.14) = 2.1970E+008
φu = φsu (4.1) = 9.6917274E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.28304984
lb = 300.00
ld = 1059.884
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80

ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 424229.688

Calculation of Shear Strength at edge 1, Vr1 = 424229.688
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23669
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 424229.688
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 424229.688

knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.23667
Vu = 0.00016213
d = 0.8*h = 480.00
Nu = 8883.864
Ag = 150000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 316483.206
where:
Vs1 = 93083.296 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.75
Vs2 = 223399.91 is calculated for section flange, with:
d = 480.00
Av = 157079.633
fy = 444.44
s = 150.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 293495.545
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) = 557.00
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 <= 356502.845
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column LC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rclcs

Constant Properties

Knowledge Factor, κ = 0.77
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44

Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
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 = 136240.323
Shear Force, V2 = 3536.316
Shear Force, V3 = -123.1168
Axial Force, F = -9530.256
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 4121.77
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1746.726
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 1545.664
Mean Diameter of Tension Reinforcement, DbL = 17.71429

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03287888
θu = θy + θp = 0.04269984

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00069984 ((4.29),Biskinis Phd))
My = 2.9338E+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 = 4.1921E+013
factor = 0.30
Ag = 237500.00
fc' = 20.00
N = 9530.256
Ec*Ig = 1.3974E+014

Calculation of Yielding Moment My

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

$Φy = Min(Φy\_ten,Φy\_com)$
Φy_ten = 4.0516275E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 277.9106
d = 557.00
ξy = 0.38426988
A = 0.02984605
B = 0.01922829
with pt = 0.01254381
pc = 0.00595605
pv = 0.01109992
N = 9530.256
b = 250.00
δ'' = 0.07719928
Φy_comp = 8.1950430E-006
with fc* (12.3, (ACI 440)) = 20.42407
fc = 20.00
fl = 0.62098351
b = bmax = 600.00
h = hmax = 600.00
Ag = 237500.00
ρg = pt + pc + pv = 0.02959978
rc = 40.00
Ae/Ac = 0.21783041
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.38317351
A = 0.02940413
B = 0.01898202
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.3538123
lb = 300.00
ld = 847.9072
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 18.00
Mean strength value of all re-bars: fy = 444.44
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.61799
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = 150.00
n = 16.00

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.62612363
d = 557.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1460.00, is the total Length of all stirrups parallel to loading (shear) direction

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 = 9530.256
Ag = 237500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02959978
b = 250.00
d = 557.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column LC1 of floor 1
At local axis: 3
Integration Section: (b)
