Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

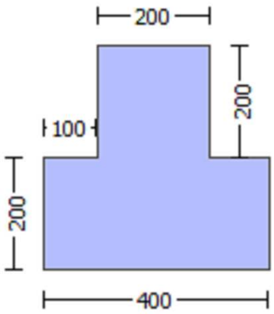
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

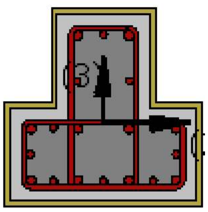
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022

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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, fc = fcm = 15.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -8.4385E+006
Shear Force, Va = -2811.342
EDGE -B-
Bending Moment, Mb = -136.3192
Shear Force, Vb = 2811.342
BOTH EDGES
Axial Force, F = -4735.965
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 2375.044
-Compression: Aslc = 2777.168
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 144111.087
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 160123.429
VCol = 160123.429
knl = 1.00
displacement_ductility_demand = 0.01556566

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
Mu = 8.4385E+006
Vu = 2811.342
d = 0.8*h = 320.00
Nu = 4735.965
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 134445.642
bw = 200.00

----
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 = 0.00032458
θy = (My*Ls/3)/EIeff = 0.02085204 ((4.29),Biskinis Phd))
My = 1.3657E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.586
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 6.5531E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4735.965
Ec*Ig = 2.1844E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8874222E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317

d = 357.00
ξy = 0.44020389
A = 0.07244171
B = 0.04070755
with pt = 0.01724796
pc = 0.01724796
pv = 0.03766391
N = 4735.965
b = 200.00
δ" = 0.12044818
Φy_comp = 1.0162905E-005
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.43961224
A = 0.0719519
B = 0.04042568
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

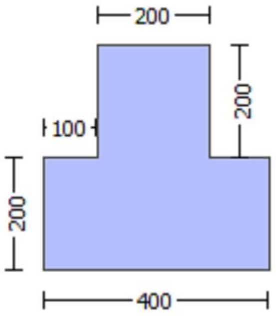
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

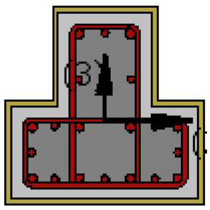
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 0.01054019
EDGE -B-
Shear Force, Vb = -0.01054019
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 0.82694402
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162085.836
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4313E+008
Mu1+ = 2.4313E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.2706E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.4313E+008
Mu2+ = 2.4313E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.2706E+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 = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008

--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu

--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185

fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794

MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016

bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 196005.816

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.21769
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 196005.816
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 196005.816
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 23.99609
Vu = 0.01054019
d = 0.8*h = 320.00

Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00

Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 1.5456333E-009
EDGE -B-
Shear Force, Vb = -1.5456333E-009
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 0.55718248
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 126675.449
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.9001E+008
Mu1+ = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9001E+008
Mu2+ = 1.9001E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.9001E+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 = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:

b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00

From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00

bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887

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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00

n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888

and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304

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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 227350.021

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00988804
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01

From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 227350.021
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00525978
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = 47.67334
Shear Force, V2 = -2811.342
Shear Force, V3 = -0.02136663
Axial Force, F = -4735.965
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 2375.044
-Compression: Aslc = 2777.168
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01664493
θu = θy + θp = 0.01849436

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01849436 ((4.29),Biskinis Phd))
My = 1.9917E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2231.206
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 8.0093E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4735.965

Ec*Ig = 2.6698E+013

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 400.00
web width, bw = 200.00
flange thickness, t = 200.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8877816E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44023806
A = 0.03622085
B = 0.0247656
with pt = 0.0075814
pc = 0.00580799
pv = 0.01443197
N = 4735.965
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.0200777E-005
with fc* (12.3, (ACI 440)) = 16.19674
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.03607992
rc = 40.00
Ae/Ac = 0.40981737
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 = 18203.022
ξy = 0.43979991
A = 0.03597638
B = 0.02462466
with Es = 200000.00
CONFIRMATION: ξy = 0.43979991 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00

n = 20.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.82694402
d = 357.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.0075814
Av = 78.53982, is the area of every stirrup
Lstir = 960.00, 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 = 4735.965
Ag = 120000.00
f'cE = 15.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(b*d) = 0.03607992
b = 400.00
d = 357.00
f'cE = 15.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

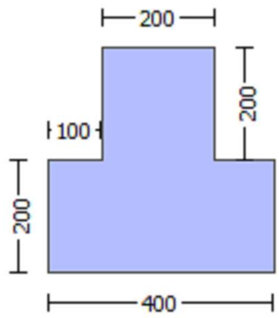
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

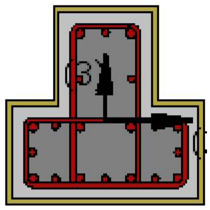
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, fc = fcm = 15.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = 47.67334

Shear Force, Va = -0.02136663
EDGE -B-
Bending Moment, Mb = 21.03175
Shear Force, Vb = 0.02136663
BOTH EDGES
Axial Force, F = -4735.965
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 2375.044
-Compression: Aslc = 2777.168
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 144111.087
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 160123.429
VCol = 160123.429
knl = 1.00
displacement_ductility_demand = 1.7523658E-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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 47.67334
Vu = 0.02136663
d = 0.8*h = 320.00
Nu = 4735.965
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 134445.642

bw = 200.00

----
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 = 3.2408892E-007
θy = (My*Ls/3)/EIeff = 0.01849436 ((4.29),Biskinis Phd))
My = 1.9917E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2231.206
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 8.0093E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4735.965
Ec*Ig = 2.6698E+013

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 400.00
web width, bw = 200.00
flange thickness, t = 200.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8877816E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44023806
A = 0.03622085
B = 0.0247656
with pt = 0.01583996
pc = 0.00580799
pv = 0.01443197
N = 4735.965
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.0200777E-005
with fc* (12.3, (ACI 440)) = 16.19674
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.03607992
rc = 40.00
Ae/Ac = 0.40981737
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 = 18203.022
ξy = 0.43979991
A = 0.03597638
B = 0.02462466
with Es = 200000.00
CONFIRMATION: ξy = 0.43979991 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

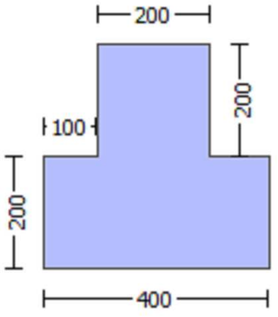
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

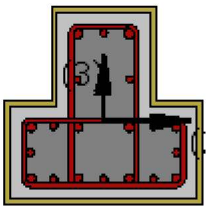
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 0.01054019
EDGE -B-
Shear Force, Vb = -0.01054019
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 0.82694402
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162085.836
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4313E+008

Mu1+ = 2.4313E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.2706E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.4313E+008
Mu2+ = 2.4313E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.2706E+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 = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00

ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00

d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578

εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   ψt = 1.00
   ψs = 0.80
   ψe = 1.00
   cb = 24.02082
   Ktr = 0.82673491
     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 = 380.00
     n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982

Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 196005.816

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.21769
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00

Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 196005.816
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 196005.816
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 23.99609
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440

with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 1.5456333E-009
EDGE -B-
Shear Force, Vb = -1.5456333E-009
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 0.55718248
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 126675.449
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.9001E+008
Mu1+ = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9001E+008
Mu2+ = 1.9001E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.9001E+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 = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.

with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667

εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562

εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 227350.021

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00988804

Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 227350.021
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00525978
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633

fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -8.4385E+006
Shear Force, V2 = -2811.342
Shear Force, V3 = -0.02136663
Axial Force, F = -4735.965
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 2375.044
-Compression: Aslc = 2777.168
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL = 17.60

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01876684
θu = θy + θp = 0.02085204

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.02085204 ((4.29),Biskinis Phd))
My = 1.3657E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.586
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 6.5531E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4735.965
Ec*Ig = 2.1844E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8874222E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44020389
A = 0.07244171
B = 0.04070755
with pt = 0.0075814
pc = 0.01724796
pv = 0.03766391
N = 4735.965
b = 200.00
δ'' = 0.12044818
Φy_comp = 1.0162905E-005
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.43961224
A = 0.0719519
B = 0.04042568
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.55718248
d = 357.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.0075814
Av = 78.53982, is the area of every stirrup
Lstir = 960.00, 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 = 4735.965
Ag = 120000.00
f'cE = 15.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(b*d) = 0.07215983
b = 200.00
d = 357.00
f'cE = 15.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

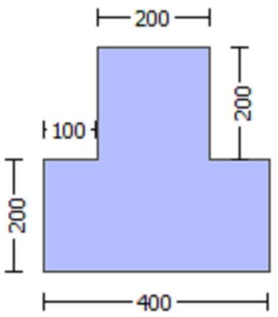
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

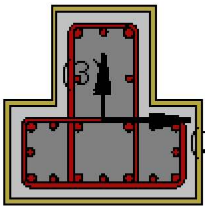
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, fc = fcm = 15.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -8.4385E+006
Shear Force, Va = -2811.342
EDGE -B-
Bending Moment, Mb = -136.3192
Shear Force, Vb = 2811.342
BOTH EDGES
Axial Force, F = -4735.965
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 167221.095
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 185801.217
VCol = 185801.217
knl = 1.00
displacement_ductility_demand = 0.09266918

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 136.3192
Vu = 2811.342
d = 0.8*h = 320.00
Nu = 4735.965
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633

fy = 400.00
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 134445.642
bw = 200.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00019313
θy = (My*Ls/3)/Eleff = 0.0020841 ((4.29),Biskinis Phd))
My = 1.3657E+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 = 6.5531E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4735.965
Ec*Ig = 2.1844E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8874222E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44020389
A = 0.07244171
B = 0.04070755
with pt = 0.01724796
pc = 0.01724796
pv = 0.03766391
N = 4735.965
b = 200.00
δ'' = 0.12044818
Φy_comp = 1.0162905E-005
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983

rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.43961224
A = 0.0719519
B = 0.04042568
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

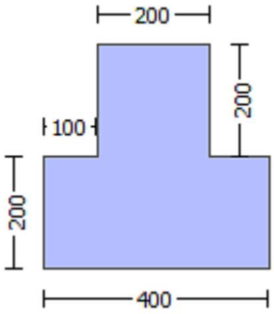
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

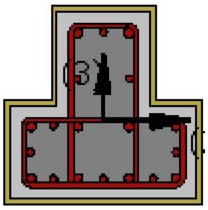
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 0.01054019
EDGE -B-

Shear Force, Vb = -0.01054019
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 0.82694402
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162085.836
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4313E+008
Mu1+ = 2.4313E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.2706E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.4313E+008
Mu2+ = 2.4313E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.2706E+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 = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00

hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->

Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00

effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185

fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082

Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875

with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887

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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 196005.816

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00

Mu = 3.21769
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 196005.816
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 196005.816
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 23.99609
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00

Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 1.5456333E-009
EDGE -B-
Shear Force, Vb = -1.5456333E-009
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 0.55718248
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 126675.449
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.9001E+008
Mu1+ = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9001E+008
Mu2+ = 1.9001E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.9001E+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 = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00

ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:

b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00

From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00

bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887

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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00

n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 227350.021

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00988804
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 227350.021
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00525978
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00

Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = 21.03175
Shear Force, V2 = 2811.342
Shear Force, V3 = 0.02136663
Axial Force, F = -4735.965
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0070088
θu = θy + θp = 0.00778756

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00778756 ((4.29),Biskinis Phd))
My = 1.9010E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 984.3271
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 8.0093E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4735.965
Ec*Ig = 2.6698E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.8134937E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.51628986

A = 0.07244171
B = 0.04953119
with pt = 0.0075814
pc = 0.01161597
pv = 0.02886393
N = 4735.965
b = 200.00
δ" = 0.12044818
Φy_comp = 8.6576330E-006
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.51604609
A = 0.0719519
B = 0.04924932
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.82694402
d = 357.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.0075814
Av = 78.53982, is the area of every stirrup
Lstir = 960.00, 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 = 4735.965
Ag = 120000.00

f'cE = 15.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(b*d) = 0.07215983
b = 200.00
d = 357.00
f'cE = 15.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

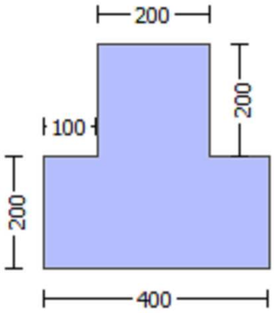
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

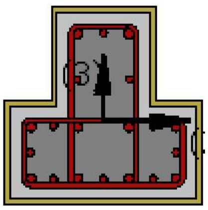
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022

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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, fc = fcm = 15.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = 47.67334
Shear Force, Va = -0.02136663
EDGE -B-
Bending Moment, Mb = 21.03175
Shear Force, Vb = 0.02136663
BOTH EDGES
Axial Force, F = -4735.965
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 151052.888
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 167836.542
VCol = 167836.542
knl = 1.00
displacement_ductility_demand = 3.9788798E-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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 3.07602
Mu = 21.03175
Vu = 0.02136663
d = 0.8*h = 320.00
Nu = 4735.965
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 134445.642
bw = 200.00

----
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 = 3.0985757E-007
θy = (My*Ls/3)/EIeff = 0.00778756 ((4.29),Biskinis Phd))
My = 1.9010E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 984.3271
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 8.0093E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4735.965
Ec*Ig = 2.6698E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.8134937E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317

d = 357.00
ξy = 0.51628986
A = 0.07244171
B = 0.04953119
with pt = 0.03167993
pc = 0.01161597
pv = 0.02886393
N = 4735.965
b = 200.00
δ" = 0.12044818
Φy_comp = 8.6576330E-006
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.51604609
A = 0.0719519
B = 0.04924932
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

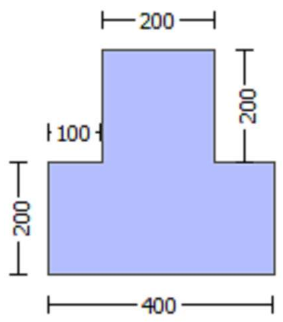
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

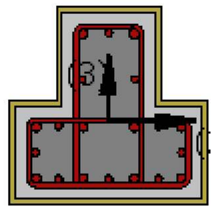
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 0.01054019
EDGE -B-
Shear Force, Vb = -0.01054019
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 0.82694402
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162085.836
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4313E+008
Mu1+ = 2.4313E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.2706E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.4313E+008
Mu2+ = 2.4313E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.2706E+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 = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008

--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185

fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794

MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016

bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 196005.816

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.21769
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 196005.816
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 196005.816
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 23.99609
Vu = 0.01054019
d = 0.8*h = 320.00

Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00

Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 1.5456333E-009
EDGE -B-
Shear Force, Vb = -1.5456333E-009
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 0.55718248
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 126675.449
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.9001E+008
Mu1+ = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9001E+008
Mu2+ = 1.9001E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.9001E+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 = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:

b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00

From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00

bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887

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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00

n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888

and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304

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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 227350.021

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00988804
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01

From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 227350.021
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00525978
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -136.3192
Shear Force, V2 = 2811.342
Shear Force, V3 = 0.02136663
Axial Force, F = -4735.965
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL = 17.60

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00187569
θu = θy + θp = 0.0020841

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0020841 ((4.29),Biskinis Phd))
My = 1.3657E+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 = 6.5531E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4735.965

Ec*Ig = 2.1844E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8874222E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44020389
A = 0.07244171
B = 0.04070755
with pt = 0.0075814
pc = 0.01724796
pv = 0.03766391
N = 4735.965
b = 200.00
δ" = 0.12044818
Φy_comp = 1.0162905E-005
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.43961224
A = 0.0719519
B = 0.04042568
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

- Calculation of θp -

From table 10-8: θp = 0.00

with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.55718248
d = 357.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.0075814
Av = 78.53982, is the area of every stirrup
Lstir = 960.00, 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 = 4735.965
Ag = 120000.00
f'cE = 15.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(b*d) = 0.07215983
b = 200.00
d = 357.00
f'cE = 15.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

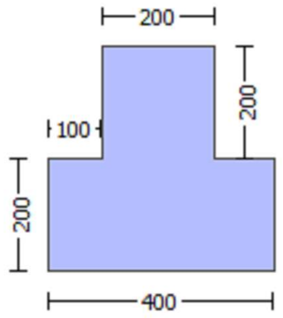
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

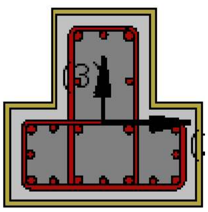
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 2
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, fc = fcm = 15.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -1.1892E+007
Shear Force, Va = -3961.043
EDGE -B-
Bending Moment, Mb = 1473.353
Shear Force, Vb = 3961.043
BOTH EDGES
Axial Force, F = -4742.638
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 2375.044
-Compression: Aslc = 2777.168
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 144111.676
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 160124.085
VCol = 160124.085
knl = 1.00
displacement_ductility_demand = 0.02386949

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.1892E+007
Vu = 3961.043
d = 0.8*h = 320.00
Nu = 4742.638
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 134445.642
bw = 200.00

----
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 = 0.00049783
θy = (My*Ls/3)/EIeff = 0.02085615 ((4.29),Biskinis Phd))
My = 1.3657E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3002.161
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 6.5531E+012
factor = 0.30
Ag = 120000.00

fc' = 15.00
N = 4742.638
Ec*Ig = 2.1844E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8874430E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44020587
A = 0.0724421
B = 0.04070795
with pt = 0.01724796
pc = 0.01724796
pv = 0.03766391
N = 4742.638
b = 200.00
δ" = 0.12044818
Φy_comp = 1.0162879E-005
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.43961339
A = 0.0719516
B = 0.04042568
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

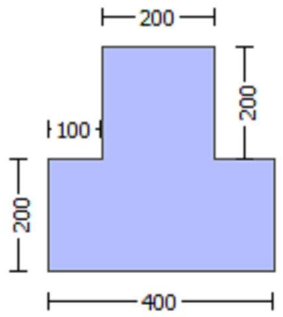
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

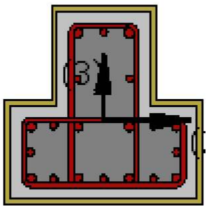
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578

Element Length, L = 3000.00
Primary 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 = 0.01054019
EDGE -B-
Shear Force, Vb = -0.01054019
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 0.82694402
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162085.836
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4313E+008
Mu1+ = 2.4313E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.2706E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.4313E+008
Mu2+ = 2.4313E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.2706E+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 = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00

d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578

εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   ψt = 1.00
   ψs = 0.80
   ψe = 1.00
   cb = 24.02082
   Ktr = 0.82673491
     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 = 380.00
     n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982

Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->

v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333

bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875

with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 196005.816

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.21769
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 196005.816

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 196005.816
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 23.99609
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 1.5456333E-009
EDGE -B-
Shear Force, Vb = -1.5456333E-009
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 0.55718248
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 126675.449
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.9001E+008
Mu1+ = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9001E+008
Mu2+ = 1.9001E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

Mu2- = 1.9001E+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 = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888

and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304

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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00

d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778

λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 227350.021

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00988804
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 227350.021
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00525978
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -1284.318
Shear Force, V2 = -3961.043
Shear Force, V3 = 0.77690092
Axial Force, F = -4742.638
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 2375.044
-Compression: Aslc = 2777.168
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0501325 θu = θy + θp = 0.05570277

 - Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01370277 ((4.29),Biskinis Phd))
   My = 1.9917E+008
   Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1653.13
   From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 8.0093E+012
      factor = 0.30
         Ag = 120000.00
         fc' = 15.00
         N = 4742.638
      Ec*Ig = 2.6698E+013

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 400.00
web width, bw = 200.00
flange thickness, t = 200.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8877969E-006
  with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
      d = 357.00
      ξy = 0.44023952
      A = 0.03622105
      B = 0.0247658
       with pt = 0.0075814
          pc = 0.00580799
          pv = 0.01443197
          N = 4742.638
          b = 400.00
          δ'' = 0.12044818
Φy_comp = 1.0200757E-005
 with fc* (12.3, (ACI 440)) = 16.19674
      fc = 15.00
      fl = 0.93147527
      b = bmax = 400.00
      h = hmax = 400.00
      Ag = 120000.00
         ρg = pt + pc + pv = 0.03607992
         rc = 40.00
         Ae/Ac = 0.40981737
         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 = 18203.022
      ξy = 0.43980075
      A = 0.03597623
      B = 0.02462466
       with Es = 200000.00
CONFIRMATION: ξy = 0.43980075 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244

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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.82694402
d = 357.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.0075814
Av = 78.53982, is the area of every stirrup
Lstir = 960.00, 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 = 4742.638
Ag = 120000.00
f'cE = 15.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(b*d) = 0.03607992
b = 400.00
d = 357.00
f'cE = 15.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

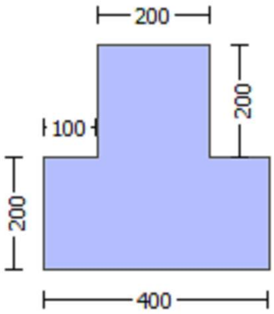
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

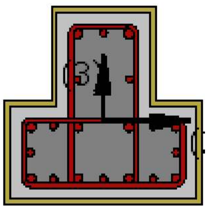
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, fc = fcm = 15.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -1284.318
Shear Force, Va = 0.77690092
EDGE -B-
Bending Moment, Mb = -853.8761
Shear Force, Vb = -0.77690092
BOTH EDGES
Axial Force, F = -4742.638
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 2375.044
-Compression: Aslc = 2777.168
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 144111.676
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 160124.085
VCol = 160124.085
knl = 1.00
displacement_ductility_demand = 0.00098248

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1284.318
Vu = 0.77690092
d = 0.8*h = 320.00
Nu = 4742.638
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 134445.642
bw = 200.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.3462679E-005
θy = (My*Ls/3)/EIeff = 0.01370277 ((4.29),Biskinis Phd))
My = 1.9917E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1653.13
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 8.0093E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4742.638
Ec*Ig = 2.6698E+013

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 400.00
web width, bw = 200.00
flange thickness, t = 200.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8877969E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44023952
A = 0.03622105
B = 0.0247658
with pt = 0.01583996
pc = 0.00580799
pv = 0.01443197
N = 4742.638
b = 400.00
δ'' = 0.12044818
Φy_comp = 1.0200757E-005
with fc* (12.3, (ACI 440)) = 16.19674
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.03607992
rc = 40.00
Ae/Ac = 0.40981737

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 = 18203.022
ξy = 0.43980075
A = 0.03597623
B = 0.02462466
with Es = 200000.00
CONFIRMATION: ξy = 0.43980075 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

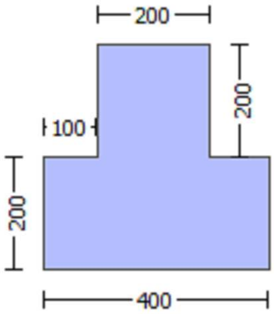
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

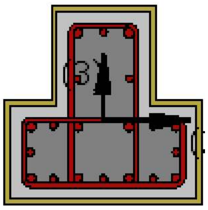
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 0.01054019
EDGE -B-

Shear Force, Vb = -0.01054019
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 0.82694402
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162085.836
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4313E+008
Mu1+ = 2.4313E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.2706E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.4313E+008
Mu2+ = 2.4313E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.2706E+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 = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00

hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->

Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00

effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185

fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082

Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875

with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887

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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 196005.816

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00

Mu = 3.21769
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 196005.816
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 196005.816
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 23.99609
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00

Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 1.5456333E-009
EDGE -B-
Shear Force, Vb = -1.5456333E-009
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 0.55718248
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 126675.449
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.9001E+008
Mu1+ = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9001E+008
Mu2+ = 1.9001E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.9001E+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 = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00

ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:

b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00

From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00

bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887

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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00

n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 227350.021

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00988804
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 227350.021
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00525978
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00

Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -1.1892E+007
Shear Force, V2 = -3961.043
Shear Force, V3 = 0.77690092
Axial Force, F = -4742.638
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 2375.044
-Compression: Aslc = 2777.168
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL = 17.60

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.05657054
θu = θy + θp = 0.06285615

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.02085615 ((4.29),Biskinis Phd))
My = 1.3657E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3002.161
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 6.5531E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4742.638
Ec*Ig = 2.1844E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8874430E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44020587

A = 0.0724421
B = 0.04070795
with pt = 0.0075814
pc = 0.01724796
pv = 0.03766391
N = 4742.638
b = 200.00
δ" = 0.12044818
Φy_comp = 1.0162879E-005
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.43961339
A = 0.0719516
B = 0.04042568
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.55718248
d = 357.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.0075814
Av = 78.53982, is the area of every stirrup
Lstir = 960.00, 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 = 4742.638
Ag = 120000.00

f'cE = 15.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(b*d) = 0.07215983
b = 200.00
d = 357.00
f'cE = 15.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

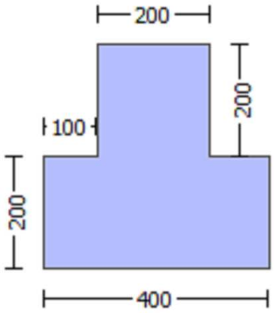
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

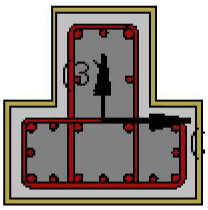
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022

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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, fc = fcm = 15.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -1.1892E+007
Shear Force, Va = -3961.043
EDGE -B-
Bending Moment, Mb = 1473.353
Shear Force, Vb = 3961.043
BOTH EDGES
Axial Force, F = -4742.638
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 167222.274
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 185802.527
VCol = 185802.527
knl = 1.00
displacement_ductility_demand = 0.13062129

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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 1473.353
Vu = 3961.043
d = 0.8*h = 320.00
Nu = 4742.638
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 134445.642
bw = 200.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00027223
θy = (My*Ls/3)/EIeff = 0.00208411 ((4.29),Biskinis Phd))
My = 1.3657E+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 = 6.5531E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4742.638
Ec*Ig = 2.1844E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8874430E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317

d = 357.00
ξy = 0.44020587
A = 0.0724421
B = 0.04070795
with pt = 0.01724796
pc = 0.01724796
pv = 0.03766391
N = 4742.638
b = 200.00
δ" = 0.12044818
Φy_comp = 1.0162879E-005
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.43961339
A = 0.0719516
B = 0.04042568
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

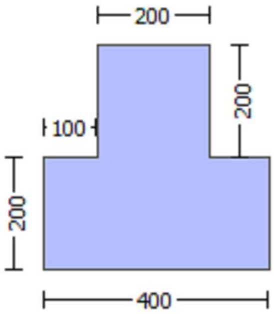
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

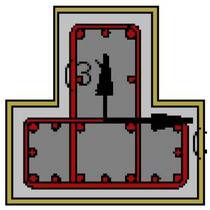
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 0.01054019
EDGE -B-
Shear Force, Vb = -0.01054019
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 0.82694402
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162085.836
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4313E+008
Mu1+ = 2.4313E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.2706E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.4313E+008
Mu2+ = 2.4313E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.2706E+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 = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008

--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185

fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794

MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016

bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 196005.816

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.21769
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 196005.816
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 196005.816
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 23.99609
Vu = 0.01054019
d = 0.8*h = 320.00

Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00

Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 1.5456333E-009
EDGE -B-
Shear Force, Vb = -1.5456333E-009
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 0.55718248
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 126675.449
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.9001E+008
Mu1+ = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9001E+008
Mu2+ = 1.9001E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.9001E+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 = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:

b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00

From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00

bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887

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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00

n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888

and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304

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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 227350.021

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00988804
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01

From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 227350.021
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00525978
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -853.8761
Shear Force, V2 = 3961.043
Shear Force, V3 = -0.77690092
Axial Force, F = -4742.638
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.04562592
θu = θy + θp = 0.05069546

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00869546 ((4.29),Biskinis Phd))
My = 1.9010E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1099.08
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 8.0093E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4742.638

Ec*Ig = 2.6698E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.8135163E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.51629147
A = 0.0724421
B = 0.04953159
with pt = 0.0075814
pc = 0.01161597
pv = 0.02886393
N = 4742.638
b = 200.00
δ'' = 0.12044818
Φy_comp = 8.6576116E-006
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.51604736
A = 0.0719516
B = 0.04924932
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

- Calculation of θp -

From table 10-8: θp = 0.042

with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
   shear control ratio VyE/VCol0E = 0.82694402
   d = 357.00
   s = 0.00
   ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.0075814
   Av = 78.53982, is the area of every stirrup
   Lstir = 960.00, 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 = 4742.638
     Ag = 120000.00
     f'cE = 15.00
     fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(b*d) = 0.07215983
   b = 200.00
   d = 357.00
     f'cE = 15.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

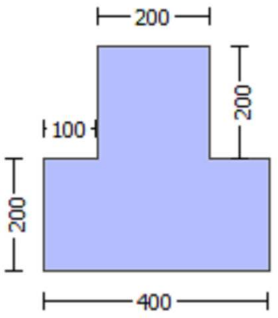
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

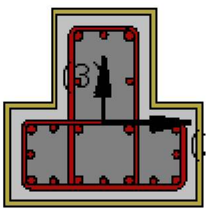
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 3
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 10.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 18203.022
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, fc = fcm = 15.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = -1284.318
Shear Force, Va = 0.77690092
EDGE -B-
Bending Moment, Mb = -853.8761
Shear Force, Vb = -0.77690092
BOTH EDGES
Axial Force, F = -4742.638
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 147915.927
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 164351.03
VCol = 164351.03
knl = 1.00
displacement_ductility_demand = 3.6025723E-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' = 10.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 3.43462
Mu = 853.8761
Vu = 0.77690092
d = 0.8*h = 320.00
Nu = 4742.638
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 400.00
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 134445.642
bw = 200.00

----
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 = 3.1326036E-007
θy = (My*Ls/3)/EIeff = 0.00869546 ((4.29),Biskinis Phd))
My = 1.9010E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1099.08
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 8.0093E+012
factor = 0.30
Ag = 120000.00

fc' = 15.00
N = 4742.638
Ec*Ig = 2.6698E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.8135163E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.51629147
A = 0.0724421
B = 0.04953159
with pt = 0.03167993
pc = 0.01161597
pv = 0.02886393
N = 4742.638
b = 200.00
δ" = 0.12044818
Φy_comp = 8.6576116E-006
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.51604736
A = 0.0719516
B = 0.04924932
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3

Integration Section: (b)

Calculation No. 16

column C1, Floor 1

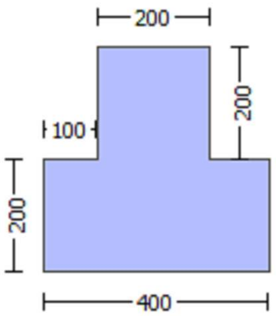
Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

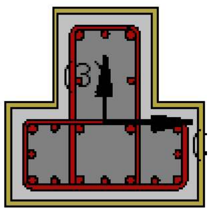
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578

Element Length, L = 3000.00
Primary 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 = 0.01054019
EDGE -B-
Shear Force, Vb = -0.01054019
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 0.82694402
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 162085.836
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4313E+008
Mu1+ = 2.4313E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.2706E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.4313E+008
Mu2+ = 2.4313E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.2706E+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 = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00

d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578

εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   ψt = 1.00
   ψs = 0.80
   ψe = 1.00
   cb = 24.02082
   Ktr = 0.82673491
     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 = 380.00
     n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982

Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.6161250E-005
Mu = 2.4313E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.53536441
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19630028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.48777647
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.83497202
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.30615641
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.76075229
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 not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.46564051
MRc (4.17) = 2.0934E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->

v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
--->
ξ*cu (4.10) = 0.55615794
MRo (4.17) = 2.4313E+008
--->
φu = φcu (4.2) = 2.6161250E-005
Mu = MRo

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.3353763E-005
Mu = 1.2706E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00221164
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333

bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875

with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09815014
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26768221
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.24388823
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1260644
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.34381201
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.31325094
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.23431248
Mu = MRc (4.14) = 1.2706E+008
φu = φsu (4.1) = 1.3353763E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 196005.816

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.21769
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 196005.816

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 196005.816
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 23.99609
Vu = 0.01054019
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.1875
Vs2 = 0.00 is calculated for section flange, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 2.375
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
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 = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.27578
Element Length, L = 3000.00
Primary 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 = 1.5456333E-009
EDGE -B-
Shear Force, Vb = -1.5456333E-009
BOTH EDGES
Axial Force, F = -4737.328
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 0.55718248
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 126675.449
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.9001E+008
Mu1+ = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.9001E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9001E+008
Mu2+ = 1.9001E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

Mu2- = 1.9001E+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 = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888

and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304

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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008
----
with full section properties:
b = 200.00
d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778
λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7086748E-005
Mu = 1.9001E+008

----

with full section properties:
b = 200.00

d = 357.00
d' = 43.00
v = 0.00442328
N = 4737.328
fc = 15.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.018
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.018
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.15303423
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 51733.333
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

ωfy = 0.15303423
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.43111111
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 400.00
hmax = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.01016
bw = 200.00
effective stress from (A.35), ff,e = 524.0792

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) = 0.00
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 = 75600.00 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 = 0.00 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 = 33066.667 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00165347
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) = 0.00165347
Lstir (Length of stirrups along Y) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00165347
Lstir (Length of stirrups along X) = 960.00
Astir (stirrups area) = 78.53982
Asec (section area) = 120000.00
----
s = 380.00
fywe = 555.55
fce = 15.00
From ((5.A5), TBDY), TBDY: εcc = 0.00475778

λc = confinement factor = 1.27578
εy1 = 0.0010562
εsh1 = 0.00365026
ft1 = 304.185
fy1 = 253.4875
εsu1 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fs1 = fs = 253.4875
with Es1 = Es = 200000.00
εy2 = 0.0010562
εsh2 = 0.00365026
ft2 = 304.185
fy2 = 253.4875
εsu2 = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.22053887
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, ASCE 41-17.
with fs2 = fs = 253.4875
with Es2 = Es = 200000.00
εyv = 0.0010562
εshv = 0.00365026
ftv = 304.185
fyv = 253.4875
εsuv = 0.00365026
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.22053887
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, ASCE 41-17.
with fsv = fs = 253.4875
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.29147618
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.29147618
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.6364888
and confined core properties:
b = 140.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 19.13667
εcc (5A.5, TBDY) = 0.00475778
λc = confinement factor = 1.27578
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.45459588
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.45459588
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.99268896
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) = 0.40159417
Mu = MRc (4.15) = 1.9001E+008
φu = φsu (4.1) = 1.7086748E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.22053887
lb = 300.00
ld = 1360.304
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 227350.021

Calculation of Shear Strength at edge 1, Vr1 = 227350.021
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00988804
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections

wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 227350.021
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 227350.021
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.00525978
Vu = 1.5456333E-009
d = 0.8*h = 320.00
Nu = 4737.328
Ag = 80000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 0.00
where:
Vs1 = 0.00 is calculated for section web, with:
d = 160.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 2.375
Vs2 = 0.00 is calculated for section flange, with:
d = 320.00
Av = 157079.633
fy = 444.44
s = 380.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.1875
Vf ((11-3)-(11.4), ACI 440) = 188111.148
ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinα + cosα is replaced with (cotθ+cota)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 357.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 164661.611
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 15.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 18203.022
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 400.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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 = 1473.353
Shear Force, V2 = 3961.043
Shear Force, V3 = -0.77690092
Axial Force, F = -4742.638
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL = 17.60

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0396757 θu = θy + θp = 0.04408411

 - Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00208411 ((4.29),Biskinis Phd))
My = 1.3657E+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 = 6.5531E+012
factor = 0.30
Ag = 120000.00
fc' = 15.00
N = 4742.638
Ec*Ig = 2.1844E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 5.8874430E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 235.317
d = 357.00
ξy = 0.44020587
A = 0.0724421
B = 0.04070795
with pt = 0.0075814
pc = 0.01724796
pv = 0.03766391
N = 4742.638
b = 200.00
δ'' = 0.12044818
Φy_comp = 1.0162879E-005
with fc* (12.3, (ACI 440)) = 16.12972
fc = 15.00
fl = 0.93147527
b = bmax = 400.00
h = hmax = 400.00
Ag = 120000.00
ρg = pt + pc + pv = 0.07215983
rc = 40.00
Ae/Ac = 0.38686758
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 = 18203.022
ξy = 0.43961339
A = 0.0719516
B = 0.04042568
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.27567359
lb = 300.00
ld = 1088.244
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' = 15.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00

ψs = 0.80
ψe = 1.00
cb = 24.02082
Ktr = 0.82673491
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 = 380.00
n = 20.00

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.55718248
d = 357.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.0075814
Av = 78.53982, is the area of every stirrup
Lstir = 960.00, 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 = 4742.638
Ag = 120000.00
f'cE = 15.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(b*d) = 0.07215983
b = 200.00
d = 357.00
f'cE = 15.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
