Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

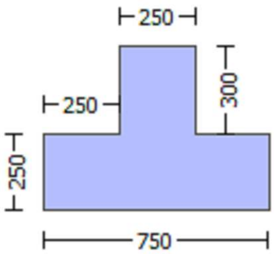
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

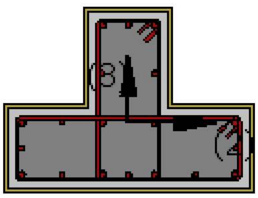
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -7.5649E+006
Shear Force, Va = -2498.291
EDGE -B-
Bending Moment, Mb = 68094.233
Shear Force, Vb = 2498.291
BOTH EDGES
Axial Force, F = -10113.234
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 = 403172.892
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 474321.05
VCol = 474321.05
knl = 1.00
displacement_ductility_demand = 0.01017851

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
Mu = 7.5649E+006
Vu = 2498.291
d = 0.8*h = 600.00
Nu = 10113.234
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 502654.825
where:
Vs1 = 125663.706 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 376991.118 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 398582.298
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 5.5165502E-005
θy = (My*Ls/3)/EIeff = 0.0054198 ((4.29),Biskinis Phd))
My = 3.1082E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3028.043
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10113.234
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.6447431E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669

d = 707.00
ξy = 0.33425369
A = 0.02937953
B = 0.01569113
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10113.234
b = 250.00
δ" = 0.06082037
Φy_comp = 7.3418097E-006
with fc* (12.3, (ACI 440)) = 20.16756
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.02914971
rc = 40.00
Ae/Ac = 0.17542991
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.33272893
A = 0.02898407
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

Calculation No. 2

column C1, Floor 1

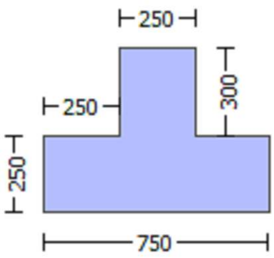
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

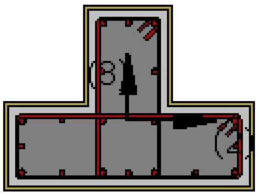
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.2472023E-020
EDGE -B-

Shear Force, Vb = -1.2472023E-020
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.68383459
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 308614.521
with
Mpr1 = Max(Mu1+ , Mu1-) = 4.6292E+008
Mu1+ = 4.6292E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.4271E+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-) = 4.6292E+008
Mu2+ = 4.6292E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.4271E+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 = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00

hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu^* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
$\varepsilon u,f$ = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
$\varepsilon y1$ = 0.0012967
$\varepsilon sh1$ = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
$\varepsilon su1$ = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911

Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:

b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087

with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451299.955

Calculation of Shear Strength at edge 1, Vr1 = 451299.955
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289

where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 451299.955
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446

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) = 507.00
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 <= 326794.274
bw = 250.00

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1

Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -7.6366595E-037
EDGE -B-
Shear Force, Vb = 7.6366595E-037
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.59737794
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 367208.942
with
Mpr1 = Max(Mu1+ , Mu1-) = 5.5081E+008
Mu1+ = 5.5081E+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- = 5.5081E+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-) = 5.5081E+008
Mu2+ = 5.5081E+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- = 5.5081E+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 = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00

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

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504

fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006

Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556

fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128

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

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087

εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 614701.214

Calculation of Shear Strength at edge 1, Vr1 = 614701.214
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 614701.214
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00

Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon

Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -109245.794
Shear Force, V2 = -2498.291
Shear Force, V3 = 55.91843
Axial Force, F = -10113.234
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 = 0.00474653
θu = θy + θp = 0.00558415

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00558415 ((4.29),Biskinis Phd))
My = 3.0228E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1953.664
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10113.234
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.3257982E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 507.00
ξy = 0.43240644
A = 0.04096909
B = 0.02754041
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10113.234
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8916924E-006
with fc* (12.3, (ACI 440)) = 20.15812
fc = 20.00

fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.04064862
rc = 40.00
Ae/Ac = 0.16554652
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.43145118
A = 0.04041751
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.68383459
d = 507.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1360.00, 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 = 10113.234
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.04064862
b = 250.00
d = 507.00
f'cE = 20.00

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

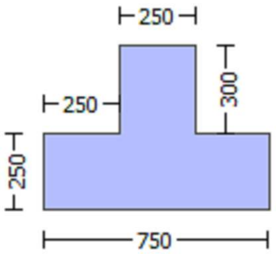
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

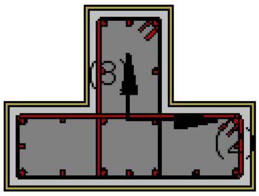
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016

Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -109245.794
Shear Force, Va = 55.91843
EDGE -B-
Bending Moment, Mb = -58129.573
Shear Force, Vb = -55.91843
BOTH EDGES
Axial Force, F = -10113.234
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 = 295885.775
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 348100.911
VCol = 348100.911
knl = 1.00
displacement_ductility_demand = 0.00194989

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 109245.794
Vu = 55.91843
d = 0.8*h = 440.00
Nu = 10113.234
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 402123.86
where:
Vs1 = 276460.154 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 125663.706 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 292293.685
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.0888489E-005
θy = (My*Ls/3)/EIeff = 0.00558415 ((4.29),Biskinis Phd))
My = 3.0228E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1953.664
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10113.234
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.3257982E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 507.00
ξy = 0.43240644
A = 0.04096909
B = 0.02754041
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10113.234
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8916924E-006
with fc* (12.3, (ACI 440)) = 20.15812
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.04064862
rc = 40.00
Ae/Ac = 0.16554652
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039

ξy = 0.43145118
A = 0.04041751
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

Calculation No. 4

column C1, Floor 1

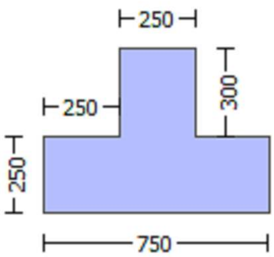
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

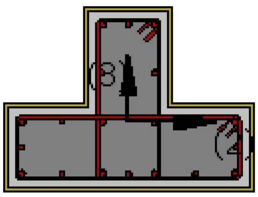
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.2472023E-020
EDGE -B-
Shear Force, Vb = -1.2472023E-020
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.68383459
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 308614.521
with
Mpr1 = Max(Mu1+ , Mu1-) = 4.6292E+008
Mu1+ = 4.6292E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.4271E+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-) = 4.6292E+008
Mu2+ = 4.6292E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.4271E+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 = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00406911

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00

fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814

ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451299.955

Calculation of Shear Strength at edge 1, Vr1 = 451299.955
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 451299.955
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -7.6366595E-037
EDGE -B-
Shear Force, Vb = 7.6366595E-037
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.59737794
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 367208.942
with
Mpr1 = Max(Mu1+ , Mu1-) = 5.5081E+008

Mu1+ = 5.5081E+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- = 5.5081E+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-) = 5.5081E+008
Mu2+ = 5.5081E+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- = 5.5081E+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 = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00

v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00406911

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504

fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211

Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087

with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 614701.214

Calculation of Shear Strength at edge 1, Vr1 = 614701.214
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667

Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 614701.214
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556

bw = 250.00

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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -7.5649E+006
Shear Force, V2 = -2498.291
Shear Force, V3 = 55.91843
Axial Force, F = -10113.234
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 = 0.00460683
θu = θy + θp = 0.0054198

 - Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0054198 ((4.29),Biskinis Phd))
My = 3.1082E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3028.043
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10113.234
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.6447431E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 707.00
ξy = 0.33425369
A = 0.02937953
B = 0.01569113
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10113.234
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.3418097E-006
with fc* (12.3, (ACI 440)) = 20.16756
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.02914971
rc = 40.00
Ae/Ac = 0.17542991
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.33272893
A = 0.02898407
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

 - Calculation of θp -

From table 10-8: θp = 0.00
with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.59737794
d = 707.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1760.00, 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 = 10113.234
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
b = 250.00
d = 707.00
f'cE = 20.00

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

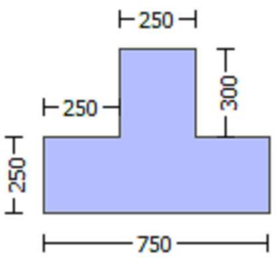
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

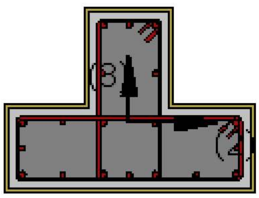
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -7.5649E+006
Shear Force, Va = -2498.291
EDGE -B-
Bending Moment, Mb = 68094.233
Shear Force, Vb = 2498.291
BOTH EDGES
Axial Force, F = -10113.234
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 = 467550.832
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 550059.802
VCol = 550059.802
knl = 1.00
displacement_ductility_demand = 0.03710501

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 68094.233
Vu = 2498.291
d = 0.8*h = 600.00
Nu = 10113.234
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 502654.825
where:
Vs1 = 125663.706 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 376991.118 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 398582.298
bw = 250.00

---

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.9923932E-005
θy = (My*Ls/3)/Eleff = 0.00053696 ((4.29),Biskinis Phd))
My = 3.1082E+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 = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10113.234

Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.6447431E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 707.00
ξy = 0.33425369
A = 0.02937953
B = 0.01569113
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10113.234
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.3418097E-006
with fc* (12.3, (ACI 440)) = 20.16756
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.02914971
rc = 40.00
Ae/Ac = 0.17542991
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.33272893
A = 0.02898407
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

Calculation No. 6

column C1, Floor 1

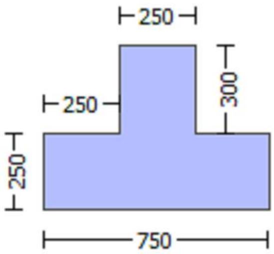
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

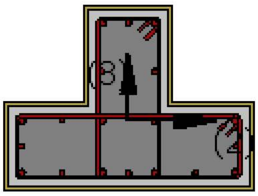
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.2472023E-020
EDGE -B-
Shear Force, Vb = -1.2472023E-020
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.68383459
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 308614.521
with
Mpr1 = Max(Mu1+ , Mu1-) = 4.6292E+008
Mu1+ = 4.6292E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.4271E+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-) = 4.6292E+008
Mu2+ = 4.6292E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.4271E+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 = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087

with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00406911

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00

hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814

ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451299.955

Calculation of Shear Strength at edge 1, Vr1 = 451299.955
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 451299.955
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00

Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -7.6366595E-037
EDGE -B-
Shear Force, Vb = 7.6366595E-037
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.59737794
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 367208.942
with
Mpr1 = Max(Mu1+ , Mu1-) = 5.5081E+008
Mu1+ = 5.5081E+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- = 5.5081E+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-) = 5.5081E+008
Mu2+ = 5.5081E+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- = 5.5081E+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 = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911

----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911

----

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----

s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 614701.214

Calculation of Shear Strength at edge 1, Vr1 = 614701.214
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 614701.214
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00

Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -58129.573
Shear Force, V2 = 2498.291
Shear Force, V3 = -55.91843
Axial Force, F = -10113.234
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 = 0.00252562
θu = θy + θp = 0.00297132

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00297132 ((4.29),Biskinis Phd))
My = 3.0228E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1039.542
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10113.234
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.3257982E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669

d = 507.00
ξy = 0.43240644
A = 0.04096909
B = 0.02754041
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10113.234
b = 250.00
δ" = 0.08481262
Φy_comp = 7.8916924E-006
with fc* (12.3, (ACI 440)) = 20.15812
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.04064862
rc = 40.00
Ae/Ac = 0.16554652
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.43145118
A = 0.04041751
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.68383459
d = 507.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1360.00, 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 = 10113.234
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.04064862
b = 250.00
d = 507.00
f'cE = 20.00

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

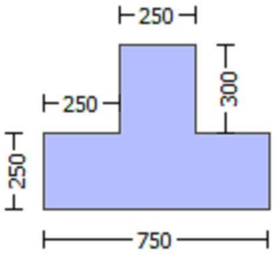
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

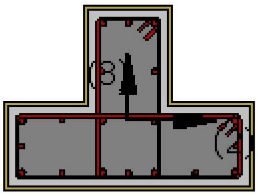
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00

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

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -109245.794
Shear Force, Va = 55.91843
EDGE -B-
Bending Moment, Mb = -58129.573
Shear Force, Vb = -55.91843
BOTH EDGES
Axial Force, F = -10113.234
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 = 328761.52
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 386778.258
VCol = 386778.258
knl = 1.00
displacement_ductility_demand = 1.1098960E-006

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.3626
Mu = 58129.573
Vu = 55.91843
d = 0.8*h = 440.00
Nu = 10113.234
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 402123.86
where:
Vs1 = 276460.154 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273

Vs2 = 125663.706 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 292293.685
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 3.2978558E-009
θy = (My*Ls/3)/EIeff = 0.00297132 ((4.29),Biskinis Phd))
My = 3.0228E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1039.542
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10113.234
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.3257982E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 507.00
ξy = 0.43240644
A = 0.04096909
B = 0.02754041
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10113.234
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8916924E-006
with fc* (12.3, (ACI 440)) = 20.15812
fc = 20.00
fl = 0.56655003
b = bmax = 750.00

h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.04064862
rc = 40.00
Ae/Ac = 0.16554652
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.43145118
A = 0.04041751
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

Calculation No. 8

column C1, Floor 1

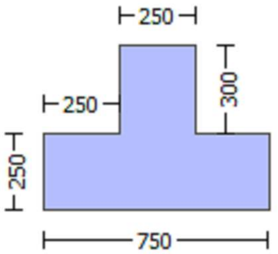
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

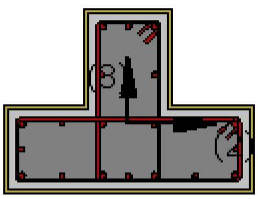
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.2472023E-020
EDGE -B-
Shear Force, Vb = -1.2472023E-020
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.68383459
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 308614.521
with

Mpr1 = Max(Mu1+ , Mu1-) = 4.6292E+008
Mu1+ = 4.6292E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.4271E+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-) = 4.6292E+008
Mu2+ = 4.6292E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.4271E+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 = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244

N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087

εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008

φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451299.955

Calculation of Shear Strength at edge 1, Vr1 = 451299.955
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 451299.955
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -7.6366595E-037
EDGE -B-
Shear Force, Vb = 7.6366595E-037
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.59737794
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 367208.942
with
Mpr1 = Max(Mu1+ , Mu1-) = 5.5081E+008
Mu1+ = 5.5081E+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- = 5.5081E+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-) = 5.5081E+008
Mu2+ = 5.5081E+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- = 5.5081E+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 = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

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

εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087

with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

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

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 614701.214

Calculation of Shear Strength at edge 1, Vr1 = 614701.214
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444

s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 614701.214
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 68094.233
Shear Force, V2 = 2498.291
Shear Force, V3 = -55.91843
Axial Force, F = -10113.234
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 = 0.00045642
θu = θy + θp = 0.00053696

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00053696 ((4.29),Biskinis Phd))
My = 3.1082E+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 = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10113.234
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.6447431E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 707.00
ξy = 0.33425369
A = 0.02937953
B = 0.01569113
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10113.234
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.3418097E-006
with fc* (12.3, (ACI 440)) = 20.16756
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.02914971
rc = 40.00
Ae/Ac = 0.17542991
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.33272893
A = 0.02898407
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

 - Calculation of θp -

From table 10-8: θp = 0.00
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VCol0E = 0.59737794
   d = 707.00
   s = 0.00
   ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
   Av = 78.53982, is the area of every stirrup
   Lstir = 1760.00, 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 = 10113.234
     Ag = 262500.00
     f'cE = 20.00
     fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
   b = 250.00
   d = 707.00
     f'cE = 20.00

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

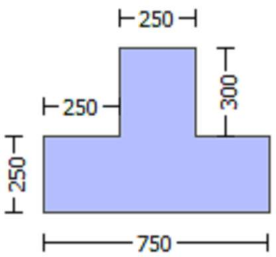
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

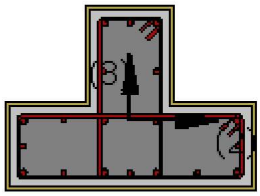
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -9.4206E+006

Shear Force, Va = -3111.113
EDGE -B-
Bending Moment, Mb = 84797.65
Shear Force, Vb = 3111.113
BOTH EDGES
Axial Force, F = -10173.552
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 = 403177.951
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 474327.002
VCol = 474327.002
knl = 1.00
displacement_ductility_demand = 0.01267465

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 9.4206E+006
Vu = 3111.113
d = 0.8*h = 600.00
Nu = 10173.552
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 502654.825
where:
Vs1 = 125663.706 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 376991.118 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 398582.298

bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 6.8697399E-005
θy = (My*Ls/3)/EIeff = 0.00542006 ((4.29),Biskinis Phd))
My = 3.1083E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3028.043
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.552
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.6447992E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 707.00
ξy = 0.33426783
A = 0.02938091
B = 0.0156925
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10173.552
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.3416963E-006
with fc* (12.3, (ACI 440)) = 20.16756
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.02914971
rc = 40.00
Ae/Ac = 0.17542991
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.33273407
A = 0.02898308
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

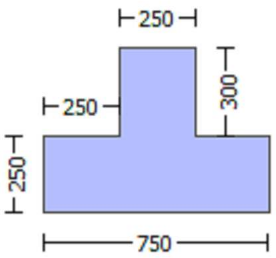
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

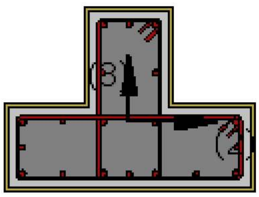
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.2472023E-020
EDGE -B-
Shear Force, Vb = -1.2472023E-020
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.68383459
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 308614.521
with
Mpr1 = Max(Mu1+ , Mu1-) = 4.6292E+008
Mu1+ = 4.6292E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.4271E+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-) = 4.6292E+008
Mu2+ = 4.6292E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.4271E+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 = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00

d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814

ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
  b = 750.00
  d = 507.00
  d' = 43.00
  v = 0.00129748
    N = 9867.335
  fc = 20.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
    The Shear_factor is considered equal to 1 (pure moment strength)
    From (5.4b), TBDY: εcu = 0.01503491
    ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
    where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

    ωfx = 0.04272593
    Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
    af = 0.14946032
    with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
      bmax = 750.00
      hmax = 550.00
      From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
        bw = 250.00
      effective stress from (A.35), ff,e = 703.4155

    ωfy = 0.04272593
    Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
    af = 0.14946032
    with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
      bmax = 750.00
      hmax = 550.00
      From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
        bw = 250.00
      effective stress from (A.35), ff,e = 703.4155

      R = 40.00
      Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
      fu,f = 1055.00
      Ef = 64828.00
      εu,f = 0.015
      ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
        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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00

bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335

fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451299.955

Calculation of Shear Strength at edge 1, Vr1 = 451299.955
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 451299.955
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -7.6366595E-037
EDGE -B-
Shear Force, Vb = 7.6366595E-037
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.59737794
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 367208.942
with
Mpr1 = Max(Mu1+ , Mu1-) = 5.5081E+008
Mu1+ = 5.5081E+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- = 5.5081E+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-) = 5.5081E+008
Mu2+ = 5.5081E+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- = 5.5081E+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 = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

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

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032

with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00

εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00406911

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 614701.214

Calculation of Shear Strength at edge 1, Vr1 = 614701.214
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 614701.214
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

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, $\kappa = 0.85$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -135772.093
Shear Force, V2 = -3111.113
Shear Force, V3 = 69.63501
Axial Force, F = -10173.552
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 $\theta_{u,R} = \kappa*\theta_u = 0.04043722$
$\theta_u = \theta_y + \theta_p = 0.0475732$

- Calculation of θ_y -

$\theta_y = (My*Ls/3)/EIeff = 0.0055732$ ((4.29),Biskinis Phd))
My = 3.0229E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1949.768
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00

fc' = 20.00
N = 10173.552
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.3258939E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 507.00
ξy = 0.432419
A = 0.04097101
B = 0.02754232
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10173.552
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8915656E-006
with fc* (12.3, (ACI 440)) = 20.15812
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.04064862
rc = 40.00
Ae/Ac = 0.16554652
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.43145811
A = 0.04041614
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.68383459
d = 507.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1360.00, 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 = 10173.552
Ag = 262500.00
f'cE = 20.00

fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.04064862
b = 250.00
d = 507.00
f'cE = 20.00

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

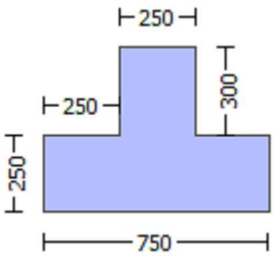
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

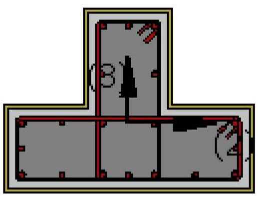
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###

Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -135772.093
Shear Force, Va = 69.63501
EDGE -B-
Bending Moment, Mb = -72659.842
Shear Force, Vb = -69.63501
BOTH EDGES
Axial Force, F = -10173.552
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 = 295890.809
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 348106.835
VCol = 348106.835
knl = 1.00
displacement_ductility_demand = 0.00243296

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 135772.093

Vu = 69.63501
d = 0.8*h = 440.00
Nu = 10173.552
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 402123.86
where:
Vs1 = 276460.154 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 125663.706 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 292293.685
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.3559395E-005
θy = (My*Ls/3)/EIeff = 0.0055732 ((4.29),Biskinis Phd))
My = 3.0229E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1949.768
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.552
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.3258939E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 507.00
ξy = 0.432419

A = 0.04097101
B = 0.02754232
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10173.552
b = 250.00
δ" = 0.08481262
Φy_comp = 7.8915656E-006
with fc* (12.3, (ACI 440)) = 20.15812
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.04064862
rc = 40.00
Ae/Ac = 0.16554652
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.43145811
A = 0.04041614
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

Calculation No. 12

column C1, Floor 1

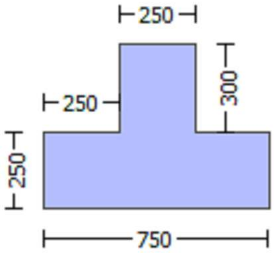
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

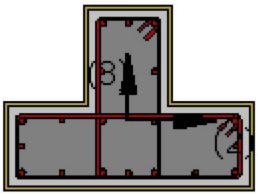
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.2472023E-020
EDGE -B-

Shear Force, Vb = -1.2472023E-020
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.68383459
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 308614.521
with
Mpr1 = Max(Mu1+ , Mu1-) = 4.6292E+008
Mu1+ = 4.6292E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.4271E+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-) = 4.6292E+008
Mu2+ = 4.6292E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.4271E+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 = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00

hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00406911

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911

Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:

b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00

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

R = 40.00

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

fu,f = 1055.00

Ef = 64828.00

εu,f = 0.015

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528

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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00406911

----

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

----

s = 100.00

fywe = 555.5556

fce = 20.00

From ((5.A5), TBDY), TBDY: εcc = 0.00511987

λc = confinement factor = 1.31199

εy1 = 0.0012967

εsh1 = 0.0044814

ft1 = 373.4504

fy1 = 311.2087

εsu1 = 0.00512

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

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

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

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

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

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

with fs1 = fs = 311.2087

with Es1 = Es = 200000.00

εy2 = 0.0012967

εsh2 = 0.0044814

ft2 = 373.4504

fy2 = 311.2087

εsu2 = 0.00512

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

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

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

with fs2 = fs = 311.2087

with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451299.955

Calculation of Shear Strength at edge 1, Vr1 = 451299.955
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289

where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 451299.955
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446

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) = 507.00
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 <= 326794.274
bw = 250.00

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1

Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -7.6366595E-037
EDGE -B-
Shear Force, Vb = 7.6366595E-037
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.59737794
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 367208.942
with
Mpr1 = Max(Mu1+ , Mu1-) = 5.5081E+008
Mu1+ = 5.5081E+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- = 5.5081E+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-) = 5.5081E+008
Mu2+ = 5.5081E+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- = 5.5081E+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 = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00

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

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504

fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006

Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00406911

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556

fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128

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

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087

εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 614701.214

Calculation of Shear Strength at edge 1, Vr1 = 614701.214
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 614701.214
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00

Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon

Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -9.4206E+006
Shear Force, V2 = -3111.113
Shear Force, V3 = 69.63501
Axial Force, F = -10173.552
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 = 0.04030705
θu = θy + θp = 0.04742006

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00542006 ((4.29),Biskinis Phd))
My = 3.1083E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3028.043
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.552
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.6447992E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 707.00
ξy = 0.33426783
A = 0.02938091
B = 0.0156925
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10173.552
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.3416963E-006
with fc* (12.3, (ACI 440)) = 20.16756
fc = 20.00

fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.02914971
rc = 40.00
Ae/Ac = 0.17542991
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.33273407
A = 0.02898308
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.59737794
d = 707.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1760.00, 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 = 10173.552
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
b = 250.00
d = 707.00
f'cE = 20.00

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

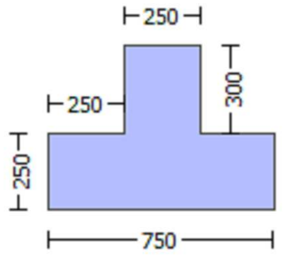
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

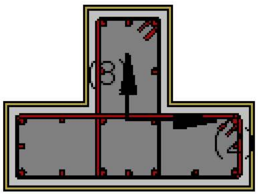
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016

Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -9.4206E+006
Shear Force, Va = -3111.113
EDGE -B-
Bending Moment, Mb = 84797.65
Shear Force, Vb = 3111.113
BOTH EDGES
Axial Force, F = -10173.552
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 = 467560.95
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 550071.706
VCol = 550071.706
knl = 1.00
displacement_ductility_demand = 0.0462045

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 84797.65
Vu = 3111.113
d = 0.8*h = 600.00
Nu = 10173.552
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 502654.825
where:
Vs1 = 125663.706 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 376991.118 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 398582.298
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.4811200E-005
θy = (My*Ls/3)/EIeff = 0.00053699 ((4.29),Biskinis Phd))
My = 3.1083E+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 = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.552
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.6447992E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 707.00
ξy = 0.33426783
A = 0.02938091
B = 0.0156925
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10173.552
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.3416963E-006
with fc* (12.3, (ACI 440)) = 20.16756
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.02914971
rc = 40.00
Ae/Ac = 0.17542991
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039

ξy = 0.33273407
A = 0.02898308
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

Calculation No. 14

column C1, Floor 1

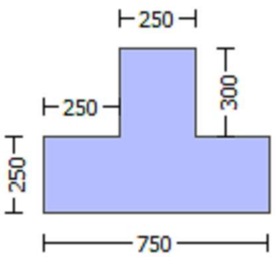
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

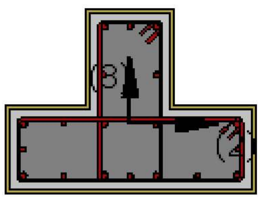
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.2472023E-020
EDGE -B-
Shear Force, Vb = -1.2472023E-020
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.68383459
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 308614.521
with
Mpr1 = Max(Mu1+ , Mu1-) = 4.6292E+008
Mu1+ = 4.6292E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.4271E+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-) = 4.6292E+008
Mu2+ = 4.6292E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.4271E+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 = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00

fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911

----

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----

s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814

ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593

Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451299.955

Calculation of Shear Strength at edge 1, Vr1 = 451299.955
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 451299.955
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -7.6366595E-037
EDGE -B-
Shear Force, Vb = 7.6366595E-037
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.59737794
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 367208.942
with
Mpr1 = Max(Mu1+ , Mu1-) = 5.5081E+008

Mu1+ = 5.5081E+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- = 5.5081E+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-) = 5.5081E+008
Mu2+ = 5.5081E+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- = 5.5081E+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 = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00

v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00406911

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504

fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211

Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087

with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 614701.214

Calculation of Shear Strength at edge 1, Vr1 = 614701.214
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667

Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 614701.214
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556

bw = 250.00

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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -72659.842
Shear Force, V2 = 3111.113
Shear Force, V3 = -69.63501
Axial Force, F = -10173.552
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 = 0.03823517
θu = θy + θp = 0.04498256

 - Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00298256 ((4.29),Biskinis Phd))
My = 3.0229E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1043.438
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.552
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.3258939E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 507.00
ξy = 0.432419
A = 0.04097101
B = 0.02754232
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10173.552
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8915656E-006
with fc* (12.3, (ACI 440)) = 20.15812
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.04064862
rc = 40.00
Ae/Ac = 0.16554652
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.43145811
A = 0.04041614
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

 - Calculation of θp -

From table 10-8: θp = 0.042
with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VCol0E = 0.68383459
  d = 507.00
  s = 0.00
  ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
  Av = 78.53982, is the area of every stirrup
  Lstir = 1360.00, 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 = 10173.552
    Ag = 262500.00
    f'cE = 20.00
    fytE = fylE = 0.00
ρl = Area_Tot_Long_Rein/(b*d) = 0.04064862
  b = 250.00
  d = 507.00
    f'cE = 20.00

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

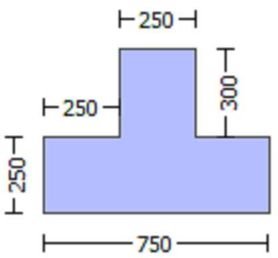
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

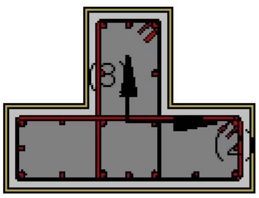
Analysis: Uniform +X

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 = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -135772.093
Shear Force, Va = 69.63501
EDGE -B-
Bending Moment, Mb = -72659.842
Shear Force, Vb = -69.63501
BOTH EDGES
Axial Force, F = -10173.552
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 = 328470.144
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 386435.464
VCol = 386435.464
knl = 1.00
displacement_ductility_demand = 1.3769428E-006

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.37145
Mu = 72659.842
Vu = 69.63501
d = 0.8*h = 440.00
Nu = 10173.552
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 402123.86
where:
Vs1 = 276460.154 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 125663.706 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 292293.685
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 4.1068078E-009
θy = (My*Ls/3)/Eleff = 0.00298256 ((4.29),Biskinis Phd))
My = 3.0229E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1043.438
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.552

Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.3258939E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669
d = 507.00
ξy = 0.432419
A = 0.04097101
B = 0.02754232
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10173.552
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8915656E-006
with fc* (12.3, (ACI 440)) = 20.15812
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.04064862
rc = 40.00
Ae/Ac = 0.16554652
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.43145811
A = 0.04041614
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

Calculation No. 16

column C1, Floor 1

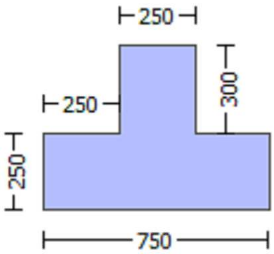
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

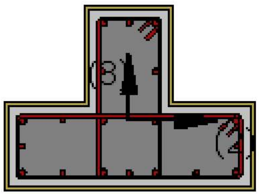
Analysis: Uniform +X

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.2472023E-020
EDGE -B-
Shear Force, Vb = -1.2472023E-020
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.68383459
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 308614.521
with
Mpr1 = Max(Mu1+ , Mu1-) = 4.6292E+008
Mu1+ = 4.6292E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.4271E+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-) = 4.6292E+008
Mu2+ = 4.6292E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.4271E+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 = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)

af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087

with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.7077737E-005
Mu = 4.6292E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.27768734
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10181869
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.25300402
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.38835783
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14239787
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35383714
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) = 0.4086676
Mu = MRc (4.15) = 4.6292E+008
φu = φsu (4.1) = 1.7077737E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.2076532E-005
Mu = 2.4271E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00

hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814

ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03393956
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09256245
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08433467
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.03921101
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10693911
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09743341
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16378152
Mu = MRc (4.14) = 2.4271E+008
φu = φsu (4.1) = 1.2076532E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 451299.955

Calculation of Shear Strength at edge 1, Vr1 = 451299.955
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 451299.955
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 451299.955
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1105.994
Vu = 1.2472023E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 446804.289
where:
Vs1 = 307177.948 is calculated for section web, with:
d = 440.00

Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.22727273
Vs2 = 139626.34 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 267149.446
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) = 507.00
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 <= 326794.274
bw = 250.00

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 = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.31199
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -7.6366595E-037
EDGE -B-
Shear Force, Vb = 7.6366595E-037
BOTH EDGES
Axial Force, F = -9867.335
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 = 0.59737794
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 367208.942
with
Mpr1 = Max(Mu1+ , Mu1-) = 5.5081E+008
Mu1+ = 5.5081E+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- = 5.5081E+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-) = 5.5081E+008
Mu2+ = 5.5081E+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- = 5.5081E+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 = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
ρsh,min = Min(ρsh,x , ρsh,y) = 0.00406911

ρsh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

ρsh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911

----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9699714E-006
Mu = 5.5081E+008
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01503491
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01503491
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.08315879
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 39233.333
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

ωfy = 0.04272593
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.14946032
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 0.00
bmax = 750.00
hmax = 550.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.008128
bw = 250.00
effective stress from (A.35), ff,e = 703.4155

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.35771528
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 = 188100.00 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 = 137025.00 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 = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00406911
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00406911
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00526591
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 100.00
fywe = 555.5556
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.00511987
λc = confinement factor = 1.31199
εy1 = 0.0012967
εsh1 = 0.0044814
ft1 = 373.4504
fy1 = 311.2087
εsu1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 311.2087
with Es1 = Es = 200000.00
εy2 = 0.0012967
εsh2 = 0.0044814
ft2 = 373.4504
fy2 = 311.2087
εsu2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 311.2087
with Es2 = Es = 200000.00
εyv = 0.0012967
εshv = 0.0044814
ftv = 373.4504
fyv = 311.2087
εsuv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 311.2087
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.1084172
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.1084172
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.23674777
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 26.23975
εcc (5A.5, TBDY) = 0.00511987
λc = confinement factor = 1.31199
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.14897567
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.14897567
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.32531422
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) = 0.27363211
Mu = MRc (4.15) = 5.5081E+008
φu = φsu (4.1) = 9.9699714E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 614701.214

Calculation of Shear Strength at edge 1, Vr1 = 614701.214
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 614701.214
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 614701.214
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61106531
Vu = 7.6366595E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 558505.361
where:
Vs1 = 139626.34 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.50
Vs2 = 418879.02 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.4444
s = 100.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.16666667
Vf ((11-3)-(11.4), ACI 440) = 372533.843
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) = 707.00
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 <= 445628.556
bw = 250.00

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 = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00

Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 84797.65
Shear Force, V2 = 3111.113
Shear Force, V3 = -69.63501
Axial Force, F = -10173.552
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 = 0.03615644
θu = θy + θp = 0.04253699

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00053699 ((4.29),Biskinis Phd))
My = 3.1083E+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 = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.552
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.6447992E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 248.9669

d = 707.00
ξy = 0.33426783
A = 0.02938091
B = 0.0156925
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10173.552
b = 250.00
δ" = 0.06082037
Φy_comp = 7.3416963E-006
with fc* (12.3, (ACI 440)) = 20.16756
fc = 20.00
fl = 0.56655003
b = bmax = 750.00
h = hmax = 550.00
Ag = 262500.00
ρg = pt + pc + pv = 0.02914971
rc = 40.00
Ae/Ac = 0.17542991
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
effective strain from (12.5) and (12.12), efe = 0.004
εfu = 0.01
Ef = 64828.00
Ec = 21019.039
ξy = 0.33273407
A = 0.02898308
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-8: θp = 0.042
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.59737794
d = 707.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1760.00, 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 = 10173.552
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
b = 250.00
d = 707.00
f'cE = 20.00

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