Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

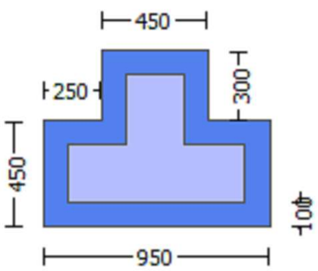
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

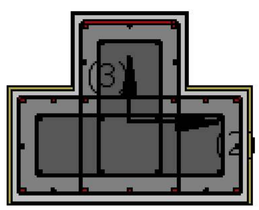
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.6491E+007
Shear Force, Va = -5469.699
EDGE -B-
Bending Moment, Mb = 78625.348
Shear Force, Vb = 5469.699
BOTH EDGES
Axial Force, F = -21155.626
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 616158.414
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 770198.017
VCol = 770198.017
knl = 1.00
displacement_ductility_demand = 0.01395201

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.80, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 3.96705
Mu = 1.6491E+007
Vu = 5469.699
d = 0.8*h = 760.00
Nu = 21155.626
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 117464.664
where:
Vs,jacket = Vs,j1 + Vs,j2 = 77252.278
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 77252.278 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 40212.386
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 40212.386 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.0362E+006
bw = 450.00

----
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 = 3.9883972E-005
θy = (My*Ls/3)/Eleff = 0.00285865 ((4.29),Biskinis Phd))
My = 7.4640E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3014.959
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.6241E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21155.626
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.7468E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.5608074E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 907.00
ξy = 0.25750796
A = 0.01654521
B = 0.00873638
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21155.626
b = 450.00
δ'' = 0.04740904
Φy_comp = 9.5511772E-006
with fc* (12.3, (ACI 440)) = 33.253
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.01639493
rc = 40.00
Ae/Ac = 0.29742395
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 = 26999.444
ξy = 0.25590825
A = 0.01627803
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1

db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

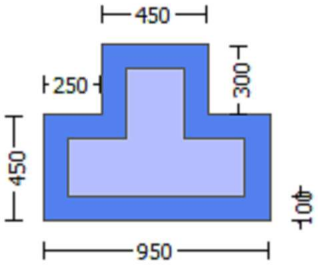
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

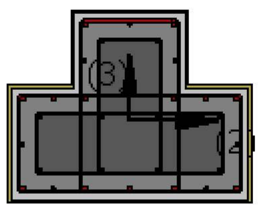
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:

Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.00053663
EDGE -B-
Shear Force, Vb = 0.00053663
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.1373

Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 604051.549
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.0608E+008
Mu1+ = 6.4320E+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- = 9.0608E+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-) = 9.0608E+008
Mu2+ = 6.4320E+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- = 9.0608E+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 = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053

fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 531127.659

Calculation of Shear Strength at edge 1, Vr1 = 531127.659
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'

where Vf is the contribution of FRPs (11.3), ACI 440).

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 531127.659
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -4.4410684E-008
EDGE -B-
Shear Force, Vb = 4.4410684E-008
BOTH EDGES
Axial Force, F = -20792.011

Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 0.60000597
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 619446.265
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2917E+008
Mu1+ = 9.2917E+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- = 9.2917E+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-) = 9.2917E+008
Mu2+ = 9.2917E+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- = 9.2917E+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 = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00

effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

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

εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667

Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606

fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0324E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0324E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62237178
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0324E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62124232
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00

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 <= 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 22361.281
Shear Force, V2 = -5469.699
Shear Force, V3 = -11.32256

Axial Force, F = -21155.626
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1859.823
-Middle: Asl,mid,jacket = 2060.885
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 615.7522
-Middle: Asl,mid,core = 615.7522
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0016485
θu = θy + θp = 0.00206063

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00206063 ((4.29),Biskinis Phd))
My = 5.4280E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1974.931
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.7341E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21155.626
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.7803E+014

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 950.00
web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0501354E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 707.00
ξy = 0.2002809
A = 0.01005424
B = 0.00472121
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21155.626
b = 950.00
δ'' = 0.06082037
Φy_comp = 1.5784005E-005
with fc* (12.3, (ACI 440)) = 33.25688
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00

Ag = 0.5625
ρg = pt + pc + pv = 0.00996292
rc = 40.00
Ae/Ac = 0.30198841
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 = 26999.444
ξy = 0.19868385
A = 0.00989188
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.19959184 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.1373
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.002894
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00049441
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 610.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00029191
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 480.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 21155.626
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 26.93333
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 514.3083
pl = Area_Tot_Long_Rein/(b*d) = 0.00996292

b = 950.00
d = 707.00
f'cE = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

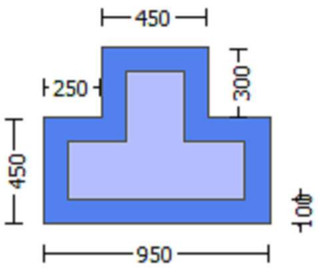
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

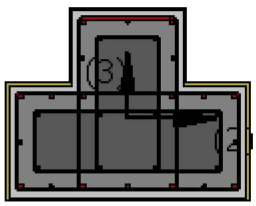
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column

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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 22361.281
Shear Force, Va = -11.32256
EDGE -B-
Bending Moment, Mb = 12193.838
Shear Force, Vb = 11.32256
BOTH EDGES
Axial Force, F = -21155.626
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 434810.915
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 543513.644
VCol = 543513.644

knl = 1.00
displacement_ductility_demand = 0.00388052

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.80, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 3.29155
Mu = 22361.281
Vu = 11.32256
d = 0.8*h = 600.00
Nu = 21155.626
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 818016.733
bw = 450.00

----

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 = 7.9963137E-006
θy = (My*Ls/3)/EIeff = 0.00206063 ((4.29),Biskinis Phd))
My = 5.4280E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1974.931
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.7341E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21155.626
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.7803E+014

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 950.00
web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0501354E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 707.00
ξy = 0.2002809
A = 0.01005424
B = 0.00472121
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21155.626
b = 950.00
δ'' = 0.06082037
Φy_comp = 1.5784005E-005
with fc* (12.3, (ACI 440)) = 33.25688
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.00996292
rc = 40.00
Ae/Ac = 0.30198841
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 = 26999.444
ξy = 0.19868385
A = 0.00989188
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.19959184 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00

ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

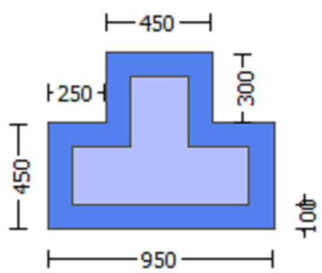
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

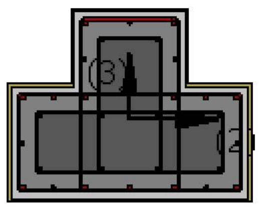
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.00053663
EDGE -B-
Shear Force, Vb = 0.00053663
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.1373
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 604051.549
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.0608E+008
Mu1+ = 6.4320E+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- = 9.0608E+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-) = 9.0608E+008
Mu2+ = 6.4320E+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- = 9.0608E+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 = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111

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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111

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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658

ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 531127.659

Calculation of Shear Strength at edge 1, Vr1 = 531127.659
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659

knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 531127.659
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -4.4410684E-008
EDGE -B-

Shear Force, Vb = 4.4410684E-008
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 0.60000597
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 619446.265
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2917E+008
Mu1+ = 9.2917E+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- = 9.2917E+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-) = 9.2917E+008
Mu2+ = 9.2917E+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- = 9.2917E+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 = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00

hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838

εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111

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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0324E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0324E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62237178
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0324E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62124232
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.6491E+007
Shear Force, V2 = -5469.699
Shear Force, V3 = -11.32256
Axial Force, F = -21155.626
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1231.504
-Middle: Asl,mid,jacket = 2689.203
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 923.6282
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00228692
θu = θy + θp = 0.00285865

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00285865 ((4.29),Biskinis Phd))
My = 7.4640E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3014.959
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.6241E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21155.626
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.7468E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.5608074E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 907.00
ξy = 0.25750796
A = 0.01654521
B = 0.00873638
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21155.626
b = 450.00
δ'' = 0.04740904
Φy_comp = 9.5511772E-006
with fc* (12.3, (ACI 440)) = 33.253
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.01639493

rc = 40.00
Ae/Ac = 0.29742395
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 = 26999.444
ξy = 0.25590825
A = 0.01627803
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.60000597
d = d_external = 907.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00306002
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00058597
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 610.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00036638
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 480.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 21155.626
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 26.93333
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 512.811
pl = Area_Tot_Long_Rein/(b*d) = 0.01639493
b = 450.00
d = 907.00
f'cE = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

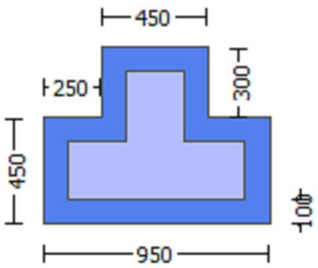
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

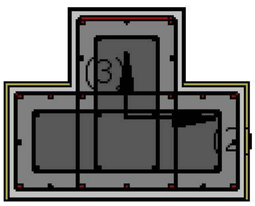
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.6491E+007
Shear Force, Va = -5469.699
EDGE -B-
Bending Moment, Mb = 78625.348
Shear Force, Vb = 5469.699
BOTH EDGES
Axial Force, F = -21155.626
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 772508.322
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 965635.403
VCol = 965635.403
knl = 1.00
displacement_ductility_demand = 0.03343893

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.80, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 78625.348
Vu = 5469.699
d = 0.8*h = 760.00
Nu = 21155.626
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 117464.664
where:
Vs,jacket = Vs,j1 + Vs,j2 = 77252.278
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 77252.278 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 40212.386
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 40212.386 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.0362E+006
bw = 450.00

----
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 = 9.5116034E-006
θy = (My*Ls/3)/Eleff = 0.00028445 ((4.29),Biskinis Phd))
My = 7.4640E+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 = 2.6241E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21155.626
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.7468E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.5608074E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 907.00
ξy = 0.25750796
A = 0.01654521
B = 0.00873638
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21155.626
b = 450.00
δ'' = 0.04740904
Φy_comp = 9.5511772E-006
with fc* (12.3, (ACI 440)) = 33.253
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.01639493
rc = 40.00
Ae/Ac = 0.29742395
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 = 26999.444
ξy = 0.25590825
A = 0.01627803
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80

ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

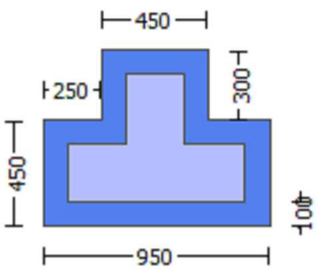
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

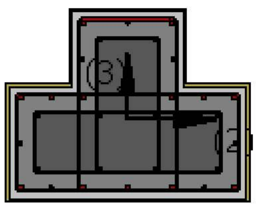
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.00053663
EDGE -B-
Shear Force, Vb = 0.00053663
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.1373
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 604051.549
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.0608E+008
Mu1+ = 6.4320E+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- = 9.0608E+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-) = 9.0608E+008
Mu2+ = 6.4320E+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- = 9.0608E+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 = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:

b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 531127.659

Calculation of Shear Strength at edge 1, Vr1 = 531127.659
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00

Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 531127.659
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -4.4410684E-008
EDGE -B-
Shear Force, Vb = 4.4410684E-008
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38

-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 0.60000597
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 619446.265
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2917E+008
Mu1+ = 9.2917E+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- = 9.2917E+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-) = 9.2917E+008
Mu2+ = 9.2917E+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- = 9.2917E+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 = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

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

εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667

Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606

fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0324E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0324E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62237178
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0324E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62124232
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 12193.838
Shear Force, V2 = 5469.699
Shear Force, V3 = 11.32256
Axial Force, F = -21155.626
Longitudinal Reinforcement Area Distribution (in 2 divisions)
    -Tension: Aslt = 0.00
    -Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
    -Tension: Asl,ten = 1539.38

-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1859.823
-Middle: Asl,mid,jacket = 2060.885
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 615.7522
-Middle: Asl,mid,core = 615.7522
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00089895
θu = θy + θp = 0.00112368

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00112368 ((4.29),Biskinis Phd))
My = 5.4280E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1076.95
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.7341E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21155.626
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.7803E+014

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 950.00
web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0501354E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 707.00
ξy = 0.2002809
A = 0.01005424
B = 0.00472121
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21155.626
b = 950.00
δ'' = 0.06082037
Φy_comp = 1.5784005E-005
with fc* (12.3, (ACI 440)) = 33.25688
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.00996292
rc = 40.00
Ae/Ac = 0.30198841
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 = 26999.444
ξy = 0.19868385
A = 0.00989188
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.19959184 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.1373
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.002894
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00049441
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 610.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00029191
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 480.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 21155.626
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 26.93333
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 514.3083
pl = Area_Tot_Long_Rein/(b*d) = 0.00996292
b = 950.00
d = 707.00
f'cE = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2

Integration Section: (b)

Calculation No. 7

column C1, Floor 1

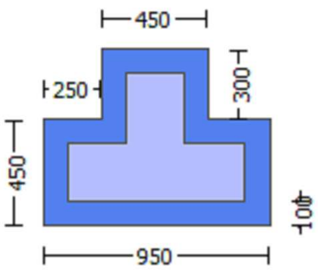
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

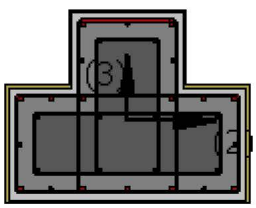
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 22361.281
Shear Force, Va = -11.32256
EDGE -B-
Bending Moment, Mb = 12193.838
Shear Force, Vb = 11.32256
BOTH EDGES
Axial Force, F = -21155.626
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 532765.565
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 665956.957
VCol = 665956.957
knl = 1.00
displacement_ductility_demand = 2.2312563E-005

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.80, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 12193.838
Vu = 11.32256
d = 0.8*h = 600.00
Nu = 21155.626
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 818016.733
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.5072237E-008

θy = (My*Ls/3)/EIeff = 0.00112368 ((4.29),Biskinis Phd))
My = 5.4280E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1076.95
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.7341E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21155.626
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.7803E+014

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 950.00
web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0501354E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 707.00
ξy = 0.2002809
A = 0.01005424
B = 0.00472121
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21155.626
b = 950.00
δ'' = 0.06082037
Φy_comp = 1.5784005E-005
with fc* (12.3, (ACI 440)) = 33.25688
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.00996292
rc = 40.00
Ae/Ac = 0.30198841
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 = 26999.444
ξy = 0.19868385
A = 0.00989188
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.19959184 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <=

8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

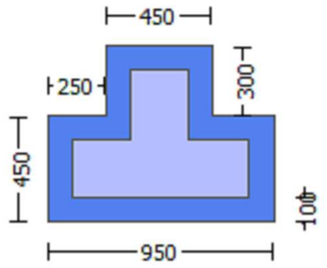
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

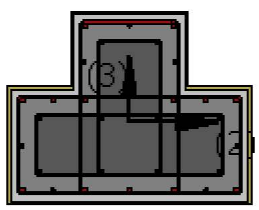
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.00053663
EDGE -B-
Shear Force, Vb = 0.00053663
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.1373
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 604051.549
with

Mpr1 = Max(Mu1+ , Mu1-) = 9.0608E+008
Mu1+ = 6.4320E+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- = 9.0608E+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-) = 9.0608E+008
Mu2+ = 6.4320E+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- = 9.0608E+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 = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111

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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658

ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006

Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799

Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 531127.659

Calculation of Shear Strength at edge 1, Vr1 = 531127.659
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 531127.659
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -4.4410684E-008
EDGE -B-
Shear Force, Vb = 4.4410684E-008
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592

Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 0.60000597
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 619446.265
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2917E+008
Mu1+ = 9.2917E+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- = 9.2917E+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-) = 9.2917E+008
Mu2+ = 9.2917E+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- = 9.2917E+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 = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111

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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111

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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0324E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0324E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62237178
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0324E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62124232
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 78625.348
Shear Force, V2 = 5469.699
Shear Force, V3 = 11.32256
Axial Force, F = -21155.626
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00

-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1231.504
-Middle: Asl,mid,jacket = 2689.203
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 923.6282
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00022756
θu = θy + θp = 0.00028445

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00028445 ((4.29),Biskinis Phd))
My = 7.4640E+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 = 2.6241E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21155.626
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.7468E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.5608074E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 907.00
ξy = 0.25750796
A = 0.01654521
B = 0.00873638
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21155.626
b = 450.00
δ'' = 0.04740904
Φy_comp = 9.5511772E-006
with fc* (12.3, (ACI 440)) = 33.253
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.01639493
rc = 40.00
Ae/Ac = 0.29742395
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 = 26999.444
ξy = 0.25590825
A = 0.01627803
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.60000597
d = d_external = 907.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00306002
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00058597
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 610.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00036638
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 480.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 21155.626
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 26.93333
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 512.811
pl = Area_Tot_Long_Rein/(b*d) = 0.01639493
b = 450.00
d = 907.00
f'cE = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

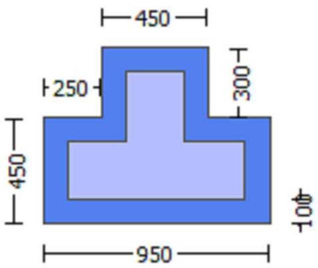
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

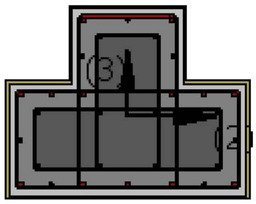
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket

New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.4941E+007
Shear Force, Va = -8272.465
EDGE -B-
Bending Moment, Mb = 118914.623
Shear Force, Vb = 8272.465
BOTH EDGES
Axial Force, F = -21341.949
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 616173.28
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 770216.601
VCol = 770216.601
knl = 1.00
displacement_ductility_demand = 0.02109944

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.80, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 3.96705
Mu = 2.4941E+007
Vu = 8272.465
d = 0.8*h = 760.00
Nu = 21341.949
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 117464.664
where:
Vs,jacket = Vs,j1 + Vs,j2 = 77252.278
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 77252.278 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 40212.386
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 40212.386 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.0362E+006
bw = 450.00

----
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 = 6.0321203E-005
θy = (My*Ls/3)/Eleff = 0.0028589 ((4.29),Biskinis Phd))
My = 7.4647E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3014.959

From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.6241E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21341.949
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.7468E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.5608734E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 907.00
ξy = 0.25752711
A = 0.01654654
B = 0.0087377
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21341.949
b = 450.00
δ'' = 0.04740904
Φy_comp = 9.5509837E-006
with fc* (12.3, (ACI 440)) = 33.253
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.01639493
rc = 40.00
Ae/Ac = 0.29742395
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 = 26999.444
ξy = 0.25591344
A = 0.016277
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00

n = 30.00

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

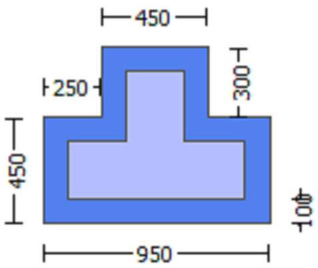
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

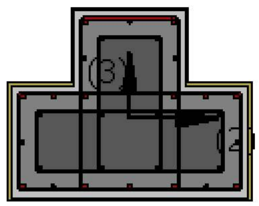
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.00053663
EDGE -B-
Shear Force, Vb = 0.00053663
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.1373
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 604051.549
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.0608E+008
Mu1+ = 6.4320E+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- = 9.0608E+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-) = 9.0608E+008
Mu2+ = 6.4320E+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- = 9.0608E+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 = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:

b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 531127.659

Calculation of Shear Strength at edge 1, Vr1 = 531127.659
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00

where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 531127.659
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:

Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -4.4410684E-008
EDGE -B-
Shear Force, Vb = 4.4410684E-008
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 0.60000597

Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 619446.265
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2917E+008
Mu1+ = 9.2917E+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- = 9.2917E+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-) = 9.2917E+008
Mu2+ = 9.2917E+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- = 9.2917E+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 = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606

fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0324E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0324E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'

where Vf is the contribution of FRPs (11.3), ACI 440).

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62237178
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0324E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62124232
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 34209.595
Shear Force, V2 = -8272.465
Shear Force, V3 = -17.12416
Axial Force, F = -21341.949
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1859.823
-Middle: Asl,mid,jacket = 2060.885

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 615.7522
-Middle: Asl,mid,core = 615.7522
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.02307538
θu = θy + θp = 0.02884422

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00208464 ((4.29),Biskinis Phd))
My = 5.4285E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1997.739
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.7341E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21341.949
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.7803E+014

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 950.00
web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0502015E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 707.00
ξy = 0.20029824
A = 0.01005504
B = 0.00472201
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21341.949
b = 950.00
δ'' = 0.06082037
Φy_comp = 1.5783736E-005
with fc* (12.3, (ACI 440)) = 33.25688
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.00996292
rc = 40.00
Ae/Ac = 0.30198841
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 = 26999.444
ξy = 0.19868723
A = 0.00989126
B = 0.00462988

with Es = 200000.00
CONFIRMATION: ξy = 0.19960317 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

- Calculation of θp -

From table 10-8: θp = 0.02675958
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.1373
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.002894
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00049441
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 610.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00029191
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 480.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 21341.949
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 26.93333
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 514.3083
pl = Area_Tot_Long_Rein/(b*d) = 0.00996292
b = 950.00
d = 707.00
f'cE = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

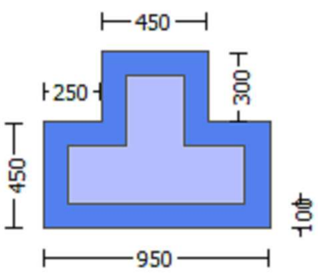
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

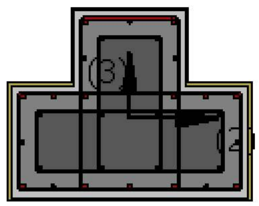
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column

Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 34209.595
Shear Force, Va = -17.12416
EDGE -B-
Bending Moment, Mb = 18052.15
Shear Force, Vb = 17.12416
BOTH EDGES
Axial Force, F = -21341.949
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 433096.84
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 541371.05
VCol = 541371.05
knl = 1.00
displacement_ductility_demand = 0.00580771

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.80, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 3.32956
Mu = 34209.595
Vu = 17.12416

d = 0.8*h = 600.00
Nu = 21341.949
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 818016.733
bw = 450.00

----
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 = 1.2106985E-005
θy = (My*Ls/3)/Eleff = 0.00208464 ((4.29),Biskinis Phd))
My = 5.4285E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1997.739
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.7341E+014
factor = 0.30
Ag = 562500.00

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21341.949
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.7803E+014

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 950.00
web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0502015E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 707.00
ξy = 0.20029824
A = 0.01005504
B = 0.00472201
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21341.949
b = 950.00
δ'' = 0.06082037
Φy_comp = 1.5783736E-005
with fc* (12.3, (ACI 440)) = 33.25688
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.00996292
rc = 40.00
Ae/Ac = 0.30198841
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 = 26999.444
ξy = 0.19868723
A = 0.00989126
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.19960317 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327

Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

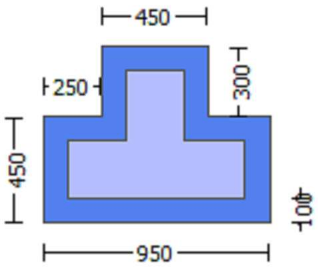
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

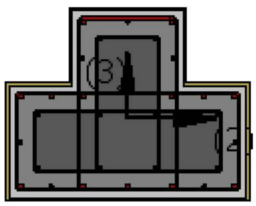
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.00053663
EDGE -B-
Shear Force, Vb = 0.00053663
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.1373
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 604051.549
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.0608E+008
Mu1+ = 6.4320E+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- = 9.0608E+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-) = 9.0608E+008

Mu2+ = 6.4320E+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- = 9.0608E+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 = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111

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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658

ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.5540806E-006

Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799

Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00

v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 531127.659

Calculation of Shear Strength at edge 1, Vr1 = 531127.659
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00

Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 531127.659
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663

d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -4.4410684E-008
EDGE -B-
Shear Force, Vb = 4.4410684E-008
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 0.60000597
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 619446.265
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2917E+008
Mu1+ = 9.2917E+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- = 9.2917E+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-) = 9.2917E+008
Mu2+ = 9.2917E+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- = 9.2917E+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 = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111

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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111

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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658

ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0324E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0324E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006

knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62237178
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0324E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62124232
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -2.4941E+007
Shear Force, V2 = -8272.465
Shear Force, V3 = -17.12416
Axial Force, F = -21341.949
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1231.504
-Middle: Asl,mid,jacket = 2689.203
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 923.6282
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.02481048
θu = θy + θp = 0.0310131

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0028589 ((4.29),Biskinis Phd))
My = 7.4647E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3014.959
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.6241E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21341.949
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.7468E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.5608734E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 907.00
ξy = 0.25752711
A = 0.01654654
B = 0.0087377
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21341.949
b = 450.00
δ'' = 0.04740904
Φy_comp = 9.5509837E-006
with fc* (12.3, (ACI 440)) = 33.253
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.01639493
rc = 40.00
Ae/Ac = 0.29742395
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 = 26999.444
ξy = 0.25591344
A = 0.016277
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 λ = 1
 db = 16.66667
 Mean strength value of all re-bars: fy = 524.4464
 Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
 ψt = 1.00
 ψs = 0.80
 ψe = 1.00
 cb = 25.00
 Ktr = 0.56308327
  Atr = Min(Atr_x,Atr_y) = 257.6106
  where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
  s = Max(s_external,s_internal) = 610.00
  n = 30.00

- Calculation of θp -

From table 10-8: θp = 0.0281542
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
 shear control ratio VyE/VCol0E = 0.60000597
 d = d_external = 907.00
 s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00306002
 jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00058597
  Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
  Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction
  s1 = 610.00
 core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00036638
  Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
  Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction
  s2 = 480.00
 The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
 where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
 All these variables have already been given in Shear control ratio calculation.
 For the normalisation fs of jacket is used.
  NUD = 21341.949
  Ag = 562500.00
  f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 26.93333
  fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
  fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 512.811
pl = Area_Tot_Long_Rein/(b*d) = 0.01639493
 b = 450.00
 d = 907.00
  f'cE = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

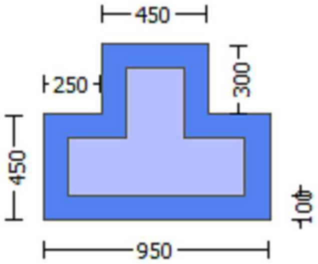
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

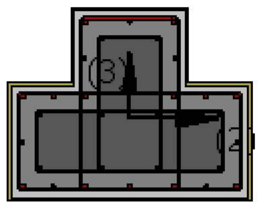
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.4941E+007
Shear Force, Va = -8272.465
EDGE -B-
Bending Moment, Mb = 118914.623
Shear Force, Vb = 8272.465
BOTH EDGES
Axial Force, F = -21341.949
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 772537.814
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 965672.268
VCol = 965672.268
knl = 1.00
displacement_ductility_demand = 0.05056926

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.80, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 118914.623
Vu = 8272.465
d = 0.8*h = 760.00
Nu = 21341.949
Ag = 427500.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 117464.664
where:
Vs,jacket = Vs,j1 + Vs,j2 = 77252.278
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 77252.278 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 40212.386
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 40212.386 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.0362E+006
bw = 450.00

----
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 = 1.4385520E-005
θy = (My*Ls/3)/EIeff = 0.00028447 ((4.29),Biskinis Phd))
My = 7.4647E+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 = 2.6241E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21341.949
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.7468E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.5608734E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 907.00
ξy = 0.25752711
A = 0.01654654
B = 0.0087377
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21341.949
b = 450.00
δ'' = 0.04740904
Φy_comp = 9.5509837E-006
with fc* (12.3, (ACI 440)) = 33.253
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.01639493
rc = 40.00
Ae/Ac = 0.29742395
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 = 26999.444
ξy = 0.25591344
A = 0.016277
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

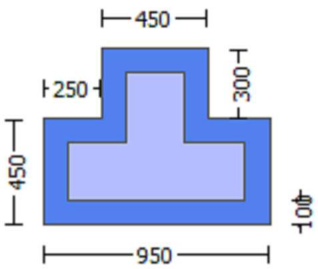
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

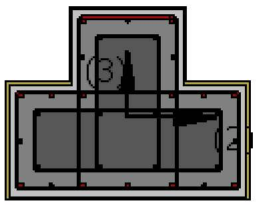
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.00053663
EDGE -B-
Shear Force, Vb = 0.00053663
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.1373
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 604051.549
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.0608E+008
Mu1+ = 6.4320E+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- = 9.0608E+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-) = 9.0608E+008
Mu2+ = 6.4320E+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- = 9.0608E+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 = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:

b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982

psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00

d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 531127.659

Calculation of Shear Strength at edge 1, Vr1 = 531127.659
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56

s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 531127.659
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633

fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -4.4410684E-008
EDGE -B-
Shear Force, Vb = 4.4410684E-008
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 0.60000597
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 619446.265
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2917E+008
Mu1+ = 9.2917E+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- = 9.2917E+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-) = 9.2917E+008
Mu2+ = 9.2917E+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- = 9.2917E+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 = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:

b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0324E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0324E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00

Mu = 0.62237178
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0324E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 0.62124232
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 18052.15
Shear Force, V2 = 8272.465
Shear Force, V3 = 17.12416
Axial Force, F = -21341.949
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1859.823
-Middle: Asl,mid,jacket = 2060.885
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 615.7522
-Middle: Asl,mid,core = 615.7522
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0222877
θu = θy + θp = 0.02785963

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00110005 ((4.29),Biskinis Phd))
My = 5.4285E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1054.192
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.7341E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21341.949
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.7803E+014

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 950.00
web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0502015E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 707.00
ξy = 0.20029824
A = 0.01005504
B = 0.00472201
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21341.949
b = 950.00
δ'' = 0.06082037
Φy_comp = 1.5783736E-005
with fc* (12.3, (ACI 440)) = 33.25688
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.00996292
rc = 40.00
Ae/Ac = 0.30198841
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 = 26999.444
ξy = 0.19868723
A = 0.00989126
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.19960317 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

- Calculation of θp -

From table 10-8: θp = 0.02675958
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.1373
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.002894
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00049441
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 610.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00029191
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 480.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 21341.949
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 26.93333
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 514.3083
pl = Area_Tot_Long_Rein/(b*d) = 0.00996292
b = 950.00
d = 707.00
f'cE = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

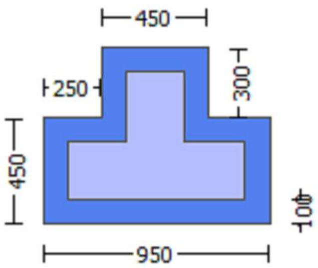
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

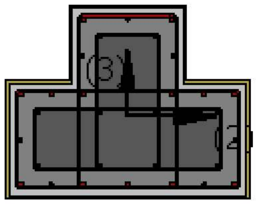
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 34209.595
Shear Force, Va = -17.12416
EDGE -B-
Bending Moment, Mb = 18052.15
Shear Force, Vb = 17.12416
BOTH EDGES
Axial Force, F = -21341.949
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 532794.974
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 665993.717
VCol = 665993.717
knl = 1.00
displacement_ductility_demand = 2.2448478E-005

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.80, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 18052.15
Vu = 17.12416
d = 0.8*h = 600.00
Nu = 21341.949
Ag = 337500.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 818016.733
bw = 450.00

---

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.4694420E-008
θy = (My*Ls/3)/EIeff = 0.00110005 ((4.29),Biskinis Phd))
My = 5.4285E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1054.192
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.7341E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21341.949
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.7803E+014

Calculation of Yielding Moment My

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

Assuming neutral axis within flange (ξy < t/d, compression zone rectangular) with:
flange width, b = 950.00
web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0502015E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 707.00
ξy = 0.20029824
A = 0.01005504
B = 0.00472201
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21341.949
b = 950.00
δ'' = 0.06082037
Φy_comp = 1.5783736E-005
with fc* (12.3, (ACI 440)) = 33.25688
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.00996292
rc = 40.00
Ae/Ac = 0.30198841
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 = 26999.444
ξy = 0.19868723
A = 0.00989126
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.19960317 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00

n = 30.00

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

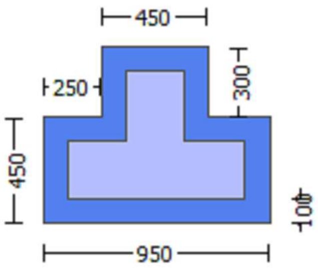
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

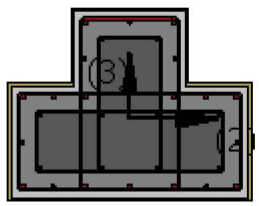
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -0.00053663
EDGE -B-
Shear Force, Vb = 0.00053663
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.1373
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 604051.549
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.0608E+008
Mu1+ = 6.4320E+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- = 9.0608E+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-) = 9.0608E+008
Mu2+ = 6.4320E+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- = 9.0608E+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 = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.5540806E-006
Mu = 6.4320E+008
----
with full section properties:

b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 444.1053
fy2 = 370.0878
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 370.0878
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02596723
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04133556
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04486853
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0289461
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04607742
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.05001568
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.15009927
Mu = MRc (4.14) = 6.4320E+008
φu = φsu (4.1) = 8.5540806E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.2331249E-006
Mu = 9.0608E+008
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.011
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 444.1053
fy1 = 370.0878
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 370.0878
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 445.8519
fyv = 371.5432
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 371.5432
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08726397
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05481971
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09472245
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10515105
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.06605648
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11413835
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.21260468
Mu = MRc (4.14) = 9.0608E+008
φu = φsu (4.1) = 9.2331249E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 531127.659

Calculation of Shear Strength at edge 1, Vr1 = 531127.659
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00

where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 531127.659
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 531127.659
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 761.1315
Vu = 0.00053663
d = 0.8*h = 600.00
Nu = 20792.011
Ag = 337500.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 0.00
where:
Vs,jacket = Vs,j1 + Vs,j2 = 0.00
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.01667
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.69444
Vs,core = Vs,c1 + Vs,c2 = 0.00
Vs,c1 = 0.00 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.09091
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 2.40
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 <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:

Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.02437
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -4.4410684E-008
EDGE -B-
Shear Force, Vb = 4.4410684E-008
BOTH EDGES
Axial Force, F = -20792.011
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 0.60000597

Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 619446.265
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2917E+008
Mu1+ = 9.2917E+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- = 9.2917E+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-) = 9.2917E+008
Mu2+ = 9.2917E+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- = 9.2917E+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 = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606

fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.9181429E-006
Mu = 9.2917E+008
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.011
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01097713
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01097713
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.03494213
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.03444474
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.28545185
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 160566.667
bmax = 950.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.10823111
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.10823111
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,max1 = 464100.00 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 external perimeter hoops.
Aconf,min1 = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.10823111
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,max2 = 252164.00 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 internal perimeter hoops.
Aconf,min2 = 4836.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 0.50551799
Expression (5.4d) for psh,min*Fywe has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.50551799
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00049441
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00029191
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.61047098
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00058597
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00036638
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 610.00
s2 = 480.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00224367
λc = confinement factor = 1.02437
εy1 = 0.00140206
εsh1 = 0.00448658
ft1 = 448.6606
fy1 = 373.8838
εsu1 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 373.8838
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00140206
εsh2 = 0.00448658
ft2 = 448.6606
fy2 = 373.8838
εsu2 = 0.00513997
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30052017
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 373.8838
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00140206
εshv = 0.00448658
ftv = 443.4583
fyv = 369.5486
εsuv = 0.00513997

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30052017
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 369.5486
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.04273157
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04273157
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09912554
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 33.80412
εcc (5A.5, TBDY) = 0.00224367
λc = confinement factor = 1.02437
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.05099229
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05099229
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.11828812
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.18084867
Mu = MRc (4.14) = 9.2917E+008
φu = φsu (4.1) = 6.9181429E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30052017
lb = 300.00
ld = 998.2691
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0324E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0324E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'

where Vf is the contribution of FRPs (11.3), ACI 440).

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62237178
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0324E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0324E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.62124232
Vu = 4.4410684E-008
d = 0.8*h = 760.00
Nu = 20792.011
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 130516.534
where:
Vs,jacket = Vs,j1 + Vs,j2 = 85836.552
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.69444
Vs,j2 = 85836.552 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 555.56
s = 610.00
Vs,j2 is multiplied by αCol,j2 = 0.78947368
s/d = 0.80263158
Vs,core = Vs,c1 + Vs,c2 = 44679.982
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 2.40
Vs,c2 = 44679.982 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 444.44
s = 480.00
Vs,c2 is multiplied by αCol,c2 = 0.80
s/d = 0.80
Vf ((11-3)-(11.4), ACI 440) = 477918.239
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) = 907.00
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 <= 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 118914.623
Shear Force, V2 = 8272.465
Shear Force, V3 = 17.12416
Axial Force, F = -21341.949
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 6691.592
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1231.504
-Middle: Asl,mid,jacket = 2689.203

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 923.6282
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.02275093
θu = θy + θp = 0.02843867

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00028447 ((4.29),Biskinis Phd))
My = 7.4647E+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 = 2.6241E+014
factor = 0.30
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333
N = 21341.949
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.7468E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 2.5608734E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 344.9102
d = 907.00
ξy = 0.25752711
A = 0.01654654
B = 0.0087377
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21341.949
b = 450.00
δ'' = 0.04740904
Φy_comp = 9.5509837E-006
with fc* (12.3, (ACI 440)) = 33.253
fc = 33.00
fl = 0.43533893
b = bmax = 950.00
h = hmax = 750.00
Ag = 0.5625
ρg = pt + pc + pv = 0.01639493
rc = 40.00
Ae/Ac = 0.29742395
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 = 26999.444
ξy = 0.25591344
A = 0.016277
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37565021
lb = 300.00
ld = 798.6153
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 26.93333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 0.56308327
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 610.00
n = 30.00

- Calculation of θp -

From table 10-8: θp = 0.0281542
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.60000597
d = d_external = 907.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00306002
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00058597
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 610.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00036638
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 480.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 21341.949
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 26.93333
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 512.811
pl = Area_Tot_Long_Rein/(b*d) = 0.01639493
b = 450.00
d = 907.00
f'cE = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)
